PixeLINK

PL-A780

FireWire

6.6 Megapixel Camera

SYSTEM GUIDE

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MAKING DIGITAL IMAGING SIMPLE

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PixeLINK™ PL-A780 6.6 Megapixel Camera System Guide

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Federal Communications Commission (FCC) Statement

FCC testing will be completed in 2004. All units shipped prior to the completion of FCC testing should be considered as prototypes and will be marked with the statement that the FCC rating is pending. Note that the PL-A780 Series is materially similar to the PL-A780 which has passed FCC and CE compliance testing.

When tested, the equipment will be measured against the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Properly shielded and grounded cables and connectors must be used to meet FCC emission limits. PixeLINK is not responsible for any radio or television interference caused by using other than recommended cables or connectors.

Unauthorized changes or modifications to the equipment could void the user's authority to operate the equipment.

European Community (CE) Statement

Testing for product safety compliance in the European Community will be completed in 2004. Units shipped prior to the completion of the testing should be considered as prototypes and will be marked indicating that the CE rating is pending. When tested, the product will be measured for compliance with the following directives and standards:

Directives:	2001/95/EC (General Product Safety Directive)—Self-declared 89/336/EEC (EMC Directive)
Standards to which conformity is declared:	
	EN55024: 1998
	EN55022: 1998 For Class B
	EN61000-3-2: 1995 EN61000-3-3: 1995
Manufacturer's Name and Address:	PixeLINK 3030 Conroy Road, Ottawa, Ontario, K1G 6C2, Canada
Type of Equipment:	PixeLINK FireWire Machine Vision Camera
Model Number:	PL-A782

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List of Manual Revisions

PL-A780 6.6 Megapixel Camera System Guide
Document Number 04646

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-01	16 June 2004		Initial release.

Related Documentation

PixeLINK Application Programming Interface (API) Reference, Part Number 04326

PixeLINK Developer's Application User's Manual, Part Number 04328

IIDC 1394-based Digital Camera Specification, Ver. 1.31, dated September 17, 2003. IEEE Trade Association Document 2003017

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1 Quick Start Instructions

Install the software you wish to use with the camera prior to connecting the camera to the computer.

To properly configure the PL-A780 for optimum image quality:

1. Plug in the camera and open the software;
2. Start the preview window.
3. Configure the Region of Interest as required to get the proper field of view.
4. Set the lens, lighting, exposure, and gain so that no areas in the image are saturated. Auto exposure will provide a good starting point;
5. Adjust the White Balance feature to match the temperature of the light source. The default is incandescent 3200º Kelvin.
6. Adjust the white point with the Auto White Shading or Auto White Balance feature. This feature uses the highest intensity areas of the scene to assess the white shading. Ensure that these areas are white or gray in color. Replace high-intensity colored objects with a gray or white card and ensure there is little or no saturation occurring in the image (i.e. gray is better than bright white).
7. Adjust gamma and saturation controls as required to achieve the best image quality.

Note that the PL-A780 camera, like any CMOS device, is subject to the physics of the sensor design. Fixed Pattern Noise (FPN), Photo Response Non Uniformity (PRNU), stuck pixels, read noise and thermal noise are an inherent part of the sensor. The effects of the noise vary with gain and exposure time. Uncorrected, these noise sources can cause significant image artifacts.

The PL-A780 corrects for these noise artifacts with pixel-by-pixel flat field correction. Internal to the camera, a gain and offset is applied to each pixel so that the overall sensor has a uniform response. In addition, stuck pixels are corrected by replacing their value with the average of the neighboring pixels.

The FFC is factory calibrated at zero gain with a standard diffuse light source and no lens. While the calibration can be used at other camera settings, it is only valid for the gain and exposure setting used during the calibration. At other settings, image artifacts may be apparent.

For the best results, it is strongly recommended that users of the PL-A780 perform a FFC calibration with the lens and lighting that will be used in the field.

A software tool is available as part of the PixeLINK Demonstration Application or Developer's Kit installation. Instructions on the process are included in the application dialog boxes.

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Before evaluating the camera on image quality, users should determine the exposure and gain settings required based on the factory calibration for the lens and lighting used in their application. Then, with the subject removed and with a uniform surface under examination, perform the FFC calibration. Once this is complete, continue with the evaluation of the image quality.

If a single gain and exposure setting is not possible, there will be practical limits on the gain and exposure times that can be used before the noise artifacts cause unacceptable degradation to the image quality.

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2 Introduction

2.1 The PL-A780 Series 6.6 Megapixel Camera

The PL-A780 Series of cameras use a 6.6 megapixel CMOS sensor to achieve high-resolution images for industrial inspection applications. The PL-A780 comes in monochrome (PL-A781) and color (PL-A782) versions suitable for industrial machine vision applications. The sensor used has 2208 (H) by 3000 (V) pixels with a pitch of 3.5 microns. The color camera uses a Bayer mosaic pattern on the sensor to detect the various colors.

Connected by FireWire, the PL-A780 is fully controlled by software on the host computer. The PL-A780 camera has a full set of controllable features, such as exposure time, gain, gamma, saturation and white balance, as well as a number of advanced features not found on ordinary machine vision cameras. These include:

- Flexible Region of Interest (ROI) controls and five levels of Pixel Addressing;
- On-board non-volatile memory for storage of camera settings; and
- Flat Field Correction (FFC) performed on each pixel on the sensor.

The high resolution allows the camera to resolve small features while maintaining a large field of view. The selectable ROI and multiple Pixel Addressing modes can be used to control the resolution of the camera or to maintain high frame rates with larger fields of view. The Pixel Addressing modes allow the resolution to be reduced by factors of 4, 9, 16, or 36 either by skipping (decimation), adding (binning), averaging or resampling the pixel data.

The on-board memory allows the camera to be configured on one computer and used on another without the need for camera configuration files or other configuration data. For example, the camera could be set up to provide a 648 x 480 field of view at 88 frames per second with a particular exposure, gamma and white balance settings and these settings programmed into the camera memory. The next time the camera is initialized, on any PC, it will default to these settings.

On-board and real-time FFC (illumination correction) is applied to every pixel on the sensor to provide image quality similar to high-end CCD cameras. For optimal image quality, the FFC can be calibrated in the field.

The PL-A780 camera has a connector for an external trigger and two General Purpose Outputs (GPO). The trigger and GPOs can be used to connect the camera to external hardware for synchronization and control. Multiple cameras can be synchronized together or lighting can be strobed by using these signals.

The PL-A780 cameras use standard FireWire interfaces for plug-and-play operation. The FireWire interface provides power, data and control communication from the host computer to the camera over a single cable. A second FireWire port on the camera can be used to connect additional cameras in a “daisy chain” on a single FireWire bus.

Fully IEEE 1394 IIDC 1.3 (IIDC) compliant, the PL-A780 can also be used with third party drivers compatible with the IIDC specification, such as the National Instruments IEEE 1394 for IMAQ driver.

However, to fully enable the camera features on Microsoft Windows systems, it is recommended to use PixeLINK supplied drivers and the PixeLINK Application Programming Interface (API) or PixeLINK Developer’s Application to control the PL-A780 camera.

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2.2 Topics Covered in this Guide

This Guide provides a reference for the PL-A780 specifications, operation, hardware and connectors. It provides detailed information for developers who will be incorporating the camera into a larger machine vision application or using the camera with IIDC drivers.

Users should consult this Guide …

- to understand the features of the PL-A780 camera
- when mounting the PL-A780 within a system or enclosure
- when planning to use an external trigger or GPO device (e.g., strobe) with the PL-A780
- when developing IIDC drivers or software for the PL-A780

References in the PDF version of this Guide are hyperlinked for easy navigation and access.

For information on programming with the PixeLINK Application Programming Interface, please refer to the *PixeLINK API Reference Manual*, Part Number 04326.

For information on the use of the PL-A780 with the PixeLINK Developer's Application, please consult the *PixeLINK Developer's Application User's Manual*, Part Number 04328.

2.3 Firmware and Hardware Versions & Variants

This guide refers to the following variants of the PL-A780.

Table 1 PL-A780 Variants

Product Number	Description	Released
PL-A781	Monochrome camera in enclosure.	
PL-A781-BL	Monochrome board level OEM module with remote head.	
PL-A782	Color camera in enclosure.	✓
PL-A782-BL	Color board level OEM module with remote head.	

The specifications of the PL-A780 cameras may change without notice. Generally, customers will not notice these changes. From time to time, PixeLINK may introduce new features or upgrades to the cameras. Upgrades to the camera firmware (the internal software that controls the camera) or the Field Programmable Gate Array (FPGA – the programmable hardware that determines the camera's features and processing) will be made available to all PL-A780 customers on the PixeLINK web site. These updates can be programmed into older cameras in the field.

The following tables list the version histories of the PL-A780 camera hardware, firmware and Field Programmable Gate Array (FPGA).

Table 2 Hardware Version History

Hardware Version	Date	Notes
129	July 04	Initial release with pre-production cameras.

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Hardware Version	Date	Notes

Table 3 Firmware Version History

Firmware Version	Date	Notes
00.01.28.00		Initial release with the pre-production cameras.

Table 4 FPGA Version History

FPGA Version	Date	Notes
66.00.23		Initial release with the pre-production cameras.

2.4 Compatibility with PixeLINK Software & Drivers

PL-A780 cameras are compatible with the following PixeLINK drivers and API software:

- PixeLINK Camera Driver, Version 4.1 and later.
- PixeLINK API, Version 4.1 and later.
- PixeLINK Developer's Application, Version 1.0.1.20 and later.

To determine the version of software and drivers installed on your host system, select Help, About PixeLINK Dev App… from the main menu of the PixeLINK Developer's Application.

To download the latest versions of the driver and application software, please visit the PixeLINK web site (http://www.pixelink.com).

For more information on software and driver compatibility or host system requirements, please refer to the *PixeLINK API Reference Manual* and the *PixeLINK Developer's Application User's Manual*.

2.5 Compatibility with 3rd Party Software & Drivers

Testing for compatibility with 3rd party software and drivers is on going. Please check the PixeLINK web site for the current list of 3rd party software packages that are compatible with the PL-A780 series cameras.

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3 PL-A780 Camera Specifications

3.1 Features

Sensor

- 2/3" CMOS 2208 x 3000 resolution (7.73 mm x 10.50 mm - 13.1 mm diagonal)
- 3.5 µm square pixels
- Rolling Shutter with fast reset capability

Frame Rate – frames per second

Table 5 Frame Rate - frames per second

ROI Size	Max Frame Rate (fps)
2208 x 3000	5
1584 x 1200	16
1272 x 1008	25
648 x 480	88

Performance

- Spectral Range 400 – 1000 nm
- FPN – TBD
- PRNU – TBD
- Dynamic Range – 56 dB linear (TBD)

Triggering / Strobe / Flash

- S/W or H/W (external) trigger (TTL to 12V)
- Two user-programmable outputs that can be used stand-alone or synchronized to trigger

Controls

- Exposure (0.063 ms to 2 seconds)
- White balance and color gains
- Gamma
- Frame Rate (max to 2 fps)
- Trigger & Strobe Modes
- Region of Interest & Pixel Addressing
- Pixel format 8-bit or 10-bit

Other Features

- Programmable LUT
- On-camera configuration memory
- FPN and PRNU correction (gain/offset correction, flat field correction – per pixel)

Compatibility

- IIDC 1.3
  - Format 0, Modes 1, 3, 5 and 6
  - Format 7

Computer Interface

- Two FireWire (IEEE 1394) connectors allow daisy chaining of the camera

Optical Interface

- Standard C-mount 1" optics
- IR cut-off protective filter

Mechanical Interface

- M3 threaded holes – 4 in front plate around C-mount and 4 in camera base

Trigger Interface

- 6 pin Hirose connector

Power Requirements

- Power supplied over the FireWire bus
- Max consumption – 5 W

Size and Weight

- Standard Configuration (PL-A782)
  H x W x L: 1.65" x 1.97" x 4.02"
  (42mm x 50mm x 102mm)
  Weight (without lens): 200g

Environmental

- FCC Class B & CE
- Shock – 50 G
- Vibration – 10 G (20 to 200 Hz)
- Temperature – 0° C to 45° C (non-condensing)

Status LED

- Flashing red and green
- Signals indicate idle, operating, warning and failed status

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3.2 Sensor

The sensor used in the PL-A780 cameras is a Fill Factory IBIS4-6600. The IBIS4-6600 is a 6.6 megapixel solid-state CMOS image sensor with 2210 x 3002 active pixels. The image size is fully programmable to a user-defined ROI. Pixels are on a 3.5 µm pitch.

The color version of the sensor uses a Bayer pattern to generate the RGB information. This is a common approach to detect color with a single sensor and is used extensively in the industry. The Bayer pattern consists of color filters placed over each pixel in alternating green/red on the odd rows and blue/green on the even rows. To determine the RGB color of any particular pixel, a Bayer to RGB conversion is performed where the color information of neighboring pixels is used to determine the missing components of the RGB color for a particular pixel. The Bayer to RGB conversion has the effect of a smearing filter and slightly reduces the effective resolution or resolving power of the sensor. It also can introduce colored artifacts into an image on the edges of high contrast areas. Resampling the image, as discussed below, can reduce both of these effects.

The monochrome version of the sensor behaves in the same manner as the color version for ROI, pixel addressing and resampling. The monochrome version does not use the Bayer pattern and Bayer to RGB conversions are not applied.

3.2.1 ROI, Pixel Addressing and Resampling

The implementation of the sensor in the PL-A780 limits the active area to 2208 x 3000. Within this Full Field of VIEW (FFOV), the ROI size and position has a granularity of 24 pixels. The minimum size of the horizontal or vertical dimensions of the ROI is 24. Possible ROI sizes are 24 x 24, 24 x 48, 48 x 48, 48 x 72, … 2208 x 3000. The top left corner of the ROI can be positioned on any row and column that is a multiple of 24.

The resolution can be reduced while maintaining the field of view by subsampling, (referred to as decimation), resampling, binning or averaging blocks of pixels. Decimation is performed by skipping blocks of pixels. The smallest block is a 2 x 2 square or four pixels. No decimation has a factor of 1 meaning every pixel block is used. To reduce the resolution by a factor of 2, every other block in a row of blocks is used and every other row of blocks is skipped. The final resolution will be ¼ of the pixels in the ROI. Decimation of 3 will skip two blocks of pixels.

The ROI can be decimated by factors of 1, 2, 3, 4 and 6. This will reduce the image size by factors of 1, 4, 9, 16 and 36 respectively. For example, with a decimation mode of 6, the FFOV ROI (2208 x 3000, 6.6 megapixels), can be reduced to 368 x 500 or 184,000 pixels while maintaining the FFOV. As the resolution and ROI are reduced, the frame rate increases as shown in Table 5 above (page on page 6).

The following figures demonstrate the effects of decimation and how the 2 x 2 pixel blocks are determined.

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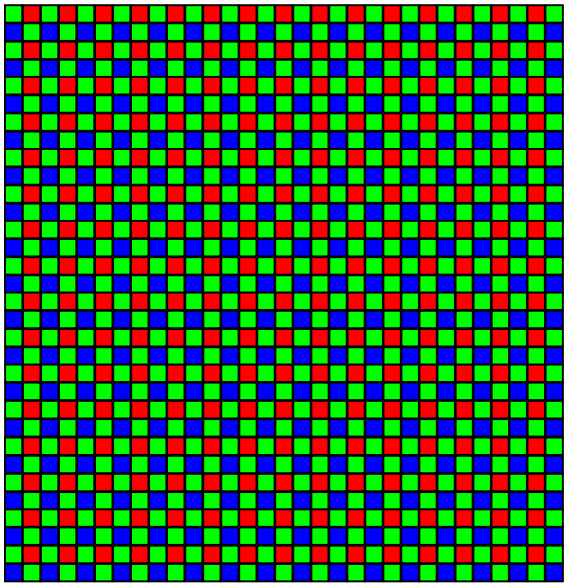

Figure 1 Color Bayer Pattern - Pixel Addressing Mode 1 (No Decimation)

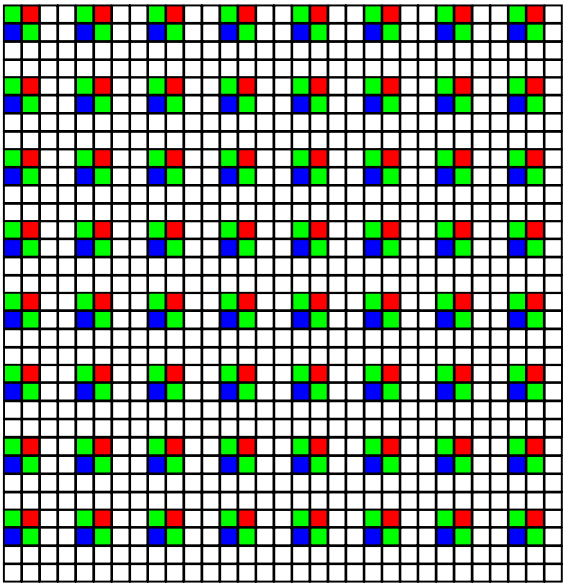

Figure 2 Color Bayer Pattern - Pixel Addressing Mode 2 (Decimation 2x)

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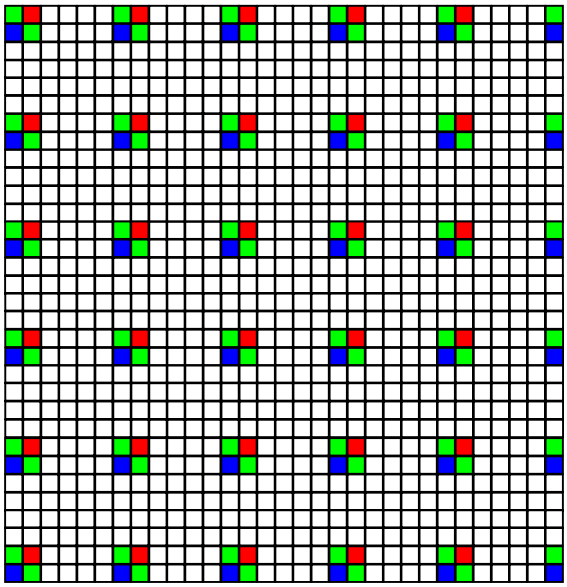

Figure 3 Color Bayer Pattern - Pixel Addressing Mode 3 (Decimation 3x)

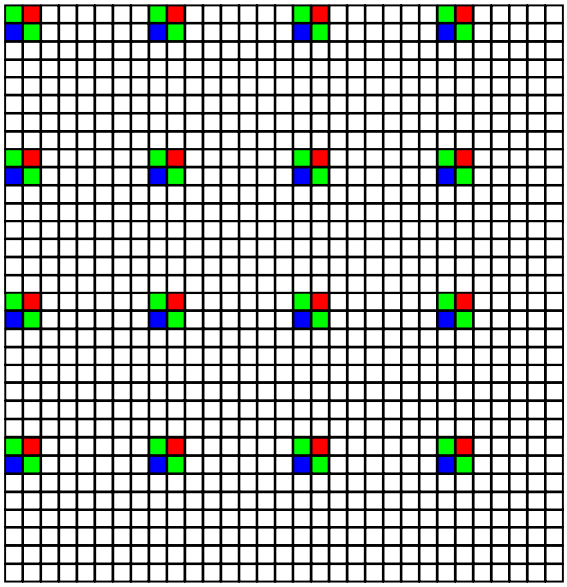

Figure 4 Color Bayer Pattern - Pixel Addressing Mode 4 (Decimation 4x)

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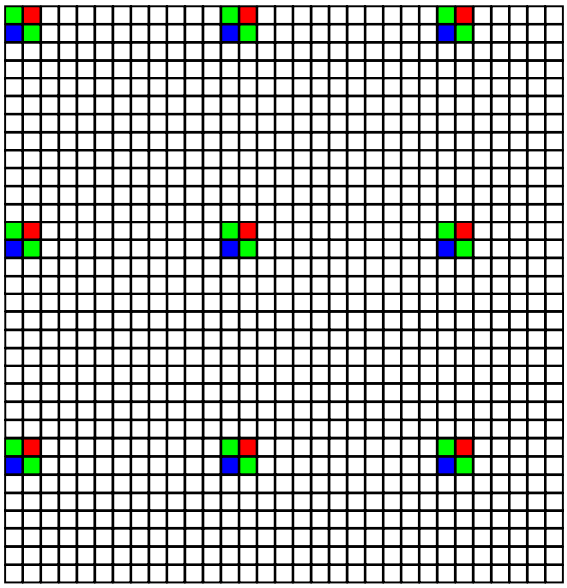

Figure 5 Color Bayer Pattern - Pixel Addressing Mode 6 (Decimation 6x)

The sensor ROI can also be resampled to combine the signals from a 2 x 2 or larger block of pixels (GRBG) into one RGB triplet. To see how this has an effect, it is important to understand that, for all other modes, the camera converts the Bayer pattern from the sensor into RGB triplets for each pixel, taking the missing values of the triplet from the surrounding pixels and creating three times the amount of image data. These RGB values are then color corrected and processed before being converted to the selected output type or Color Coding (see Section 5.1.3.2 on page 31) for transmission to the host. When the output type is Raw or Bayer, the RGB image data is converted back to Bayer by dropping two thirds of the data and only transmitting the remaining third as a Bayer pattern. At the host, the Bayer pattern is converted back to RGB for display. The Bayer to RGB conversion uses algorithms that have an effect similar to smoothing filters and image detail is slightly blurred each time the conversion is performed.

When outputting in YUV422, no Bayer to RGB conversions are performed at the host. All the intensity information is transmitted along with half the color information of the RGB image. The resulting transmission uses more bandwidth and the frame rate will be reduced but the image will have more detail.

By combining blocks of pixels to one RGB triplet, resampling does not use data from neighboring pixels so no smoothing occurs. Resampling effectively reduces the image resolution and increases the pixel size. Resampling also results in sharper image quality compared to decimation or averaging which are affected by the Bayer to RGB conversions discussed above. For the best results, the output type or Color Coding should be set to YUV422 when using resampling.

Figure 6 below shows the effects of the various modes of Pixel Addressing on image quality. The images are of a Nyquist chart. Figure 6 a. shows the full resolution image with no decimation, averaging or resampling. The colors that appear in the chart are a result of the Bayer pattern. They occur when the fine lines in the chart cover certain colors in the Bayer mosaic on the sensor. The regular patterns in the Nyquist chart exaggerate the effect. The appearance of the colors is an indication of good focus in the image, but they do detract from

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image quality. Defocusing the lens slightly to blur the lines in the image can eliminate the colors.

Decimation reduces the image resolution but will introduce more artifacts as seen in Figure 6 b. The image has been magnified to allow comparison with Figure 6 a. The benefit of using decimation is mainly the increased frame rate possible with the reduced resolution.

Averaging, as shown in Figure 6 c., pretty much eliminates the artifacts from the Bayer pattern. It has much the same effect as defocusing the lens and the image appears slightly smeared.

Figure 6 d. shows that resampling provides the best overall image quality of the Pixel Addressing modes. There are still Bayer artifacts but they are reduced and the sharpness in the image is retained. For resampling to work properly, the Color Coding needs to be set to YUV422.

a. 1248 x 288
Full resolution

b. 1248 x 288
Decimated by 3
Final image size 416 x 96

c. 1248 x 288
Averaged by 3
Final image size 416 x 96

d. 1248 x 288
Resampled by 3 (YUV422)
Final image size 416 x 96

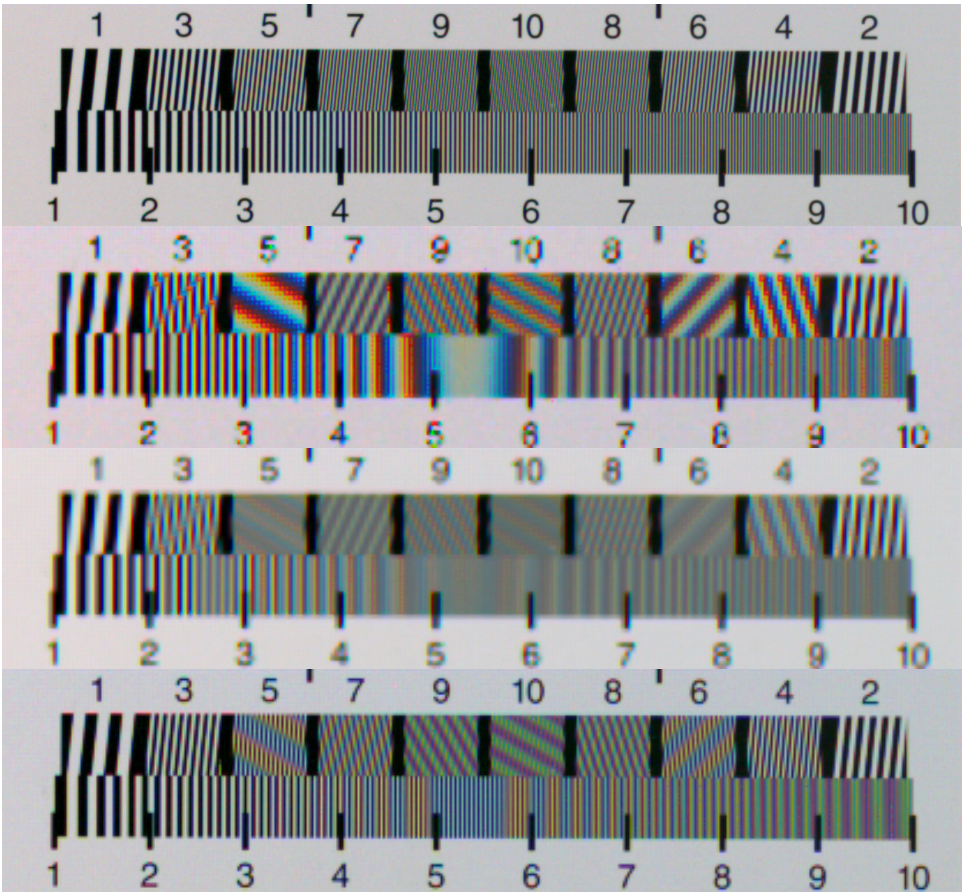

Figure 6 Examples of the effects of Decimation, Resampling and Averaging on Image Quality

Binning will provide image quality similar to the averaging mode, but the image will be much brighter – by roughly the square of the Pixel Addressing factor. Note that in CMOS sensors, the binning is performed off-chip (after the conversion from analog to digital), so there is no increase in sensitivity or speed (frame rate) compared with the non-binning mode.

Which Pixel Addressing mode is used depends on the objectives. For the very best image quality when capturing images for printing or analysis, use the full resolution. For fast video

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preview at high frame rates with short exposure times, use the decimation mode. For slower, high quality video preview or when exposure times are long, use resampling.

3.2.2 Bit Depth

The analog image data from the sensor is digitized to 12-bits and then truncated to 10-bits prior to image processing in the camera electronics. Full gain and offset corrections are performed along with pixel correction to eliminate fixed pattern noise (FPN) and Photo Response Non Uniformity (PRNU). On color cameras, color corrections are performed to convert sensor RGB to calibrated RGB for accurate color reproduction. The output data stream can be set to either 8-bit or 10-bit mode. In 10-bit mode, the 10-bit data is padded with zeros in the least significant bits to create 16-bit words. Compared to the 8-bit mode, the 10-bit mode requires twice the bandwidth on the FireWire bus and will result in a drop in frame rate.

3.2.3 Timing, Performance and Data Rates

The PL-A780 sensor uses a 40 MHz pixel clock to read out pixel data at 25 nanoseconds per pixel. Each row also has a delay of 7.3 µseconds and is padded with 10 isolation pixels. The minimum row readout time, in microseconds, is given by

$$MinRowreadoutTime(\mu s) = 7.3\mu s + 25ns * (Npixels + 10)/1000$$

where *Npixels* is the number of active pixels in the row. For the full ROI, the row readout time is 7.3+25*(2208+10)/1000 = 62.75 µs/row.

For Rolling Shutter operation (see Section 3.2.4 below) with very short exposures, the minimum frame interval can be calculated by multiplying the minimum row readout time by the number of rows in the image. For example, with a 1200 x 960 ROI, decimated by 2, the output image would be 600 x 480. This ROI could be readout once every 480*(7.3 +25*600/1000)/1000 = 10.7 milliseconds or at a maximum frame rate of 93.4 frames per second. In this example, the maximum frame rate is valid for exposures of 10.7 milliseconds or less. For exposures greater than 10.7 milliseconds, the frame rate is a function of the exposure time.

For Fast Reset Shutter operation (see Section 3.2.4 below), the minimum frame interval can be found by adding together the row reset time of 3.55 µseconds/row, the integration time and the minimum row readout time calculated above. Using the example above and assuming a 2 millisecond exposure time, the minimum frame interval is 10.7 + 2 + 3.55*480/1000 = 14.40 milliseconds which gives a maximum frame rate of 69.5 frames per second.

The above calculations determine the maximum frame rates possible. The actual frame rates achieved depend on the camera's bandwidth controls, other traffic on the FireWire bus, and the resources available on the host computer.

3.2.4 Operating Modes - Rolling Shutter and Fast Reset Shutter

The PL-A780 has two shutter types:

- Rolling Shutter (free-running image capture activated when the trigger feature is turned off); and
- Fast Reset Shutter (triggered image capture activated when the trigger feature is turned on)

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3.2.4.1 Rolling Shutter

With a Rolling Shutter, only a few rows of pixels are exposed at one time. The camera builds a frame by reading out the most exposed row of pixels (and ceasing exposure of that row), starting exposure of the next unexposed row down in the ROI, then repeating the process on the next most exposed row and continuing until the frame is complete. After the bottom row of the ROI starts its exposure, the process "rolls" to the top row of the ROI to begin exposure of the next frame's pixels.

The exposure down each frame, and from frame-to-frame, remains consistent due to this continuous read-out.

The row read-out rate is constant, so the longer the exposure setting, the greater the number of rows being exposed, or integrated, at a given time. Rows are added to the exposed area one at a time. The more time that a row spends being integrated, the greater the electrical charge built up in the row's pixels and the brighter the output pixels will be. As each fully exposed row is read out, another row is added to the set of rows being integrated.

Example: A very short exposure may be obtained by having only three rows of integration (see Figure 7 below). This means that as each row is being read out, the three rows ahead of it are being exposed. As each row is read out, another row is added to the group of rows being integrated.

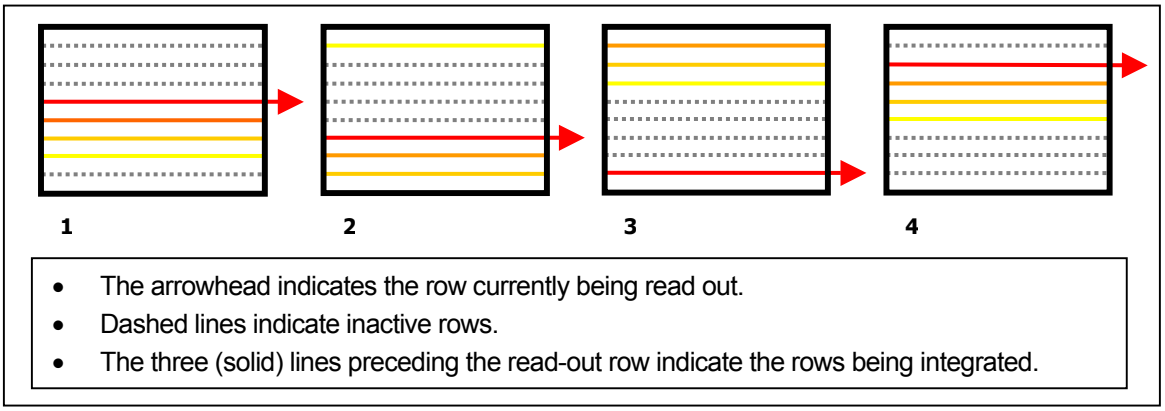
1
2
3
4
• The arrowhead indicates the row currently being read out.
• Dashed lines indicate inactive rows.
• The three (solid) lines preceding the read-out row indicate the rows being integrated.

Figure 7 Rolling Shutter Integration and Read-Out

Because Rolling Shutter exposes rows in the integration area while reading out fully exposed rows (that is, it does not stop exposure to perform read-out), it provides evenly exposed image data with the greatest possible speed (under the given parameters).

Each row of pixels has a slightly different exposure start and end times from the adjacent rows, so Rolling Shutter can produce a distorted effect when imaging moving subjects, even with very short exposure times. The distortion is due to the comparatively lengthy process of readout compared to exposure. For example, to readout the entire PL-A780 frame requires approximately 250 milliseconds. While a short exposure may stop a moving object, the same object can move appreciably in the quarter second that it takes to readout the frame resulting in distortion in the direction of motion.

For best results, rolling shutter should be used with constant illumination and with a static subject. If strobe illumination is required or the object is moving, the Fast Reset Shutter mode should be used.

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3.2.4.2 Fast Reset Shutter

With Fast Reset Shutter, all rows in the ROI are reset, row-by-row, then exposed simultaneously for a specified time. At the end of the exposure time the pixel values are read out row-by-row. The row-by-row reset is faster than the readout process but it is not instant or global. **It takes 3.5 µseconds per row to reset the array and rows at the top of the ROI start integration as soon as they are reset.** For the full field of view, the reset operation will take 11 milliseconds. Smaller ROIs or decimation will reduce the number or rows and hence, the reset time required.

The integration time starts once the array has been fully reset. When the integration time is complete, readout of the image data starts. **During the readout period, the pixels that have not yet been read are still sensitive and will continue to integrate.** The readout period can be determined from the equation in Section 3.2.3 on page 12. For the full ROI, the readout time is 62.75 µs/row or 188.2 milliseconds. All combined, the frame interval from trigger to completion of readout is 199.2 milliseconds plus the integration time.

Fast Reset Shutter requires a trigger event to reset the pixel data and start exposure for the entire ROI (as opposed to Rolling Shutter, in which exposure is an on-going process). This trigger event can be generated internally in the camera hardware, externally via the trigger input MV connector (Section 4.6.2) or by software. The PL-A780 provides a number of features to control the trigger timing and synchronize with external devices through General Purpose Outputs (GPOs). See Sections 5.1.3.10 and Section 5.1.4.4 for more information.

Careful attention to the illumination is required for the best results. In Fast Reset Shutter mode, strobe illumination should be used and the ambient light should be minimized. If using the camera in a brightly lit environment, a mechanical shutter may be required to achieve acceptable image quality.

To simplify the control of lighting when using the Fast Reset Shutter, the PL-A780 GPOs can output a Flash Window that indicates the period of time following the completion of the array reset and the start of readout. The duration of this signal is equivalent to the integration time. This signal can be used to fire a flash and control the duration of the flash to match the exposure time. Hence, regardless of the number of rows in the ROI, the illumination will be correctly applied. See Section 8.2.4 on page 55 for more information

If using an external system of the GPOs in Strobe mode, the delay from the start of integration (the trigger event with zero delay) and the start of the flash should be set to 3.5 µs x (N + 10), where N is the number of rows in the image. The flash duration should not exceed the exposure time. This will ensure the flash fires after the reset sequence is complete and completes firing before readout commences.

For example, assume the PL-A780 is being used to capture full resolution images of a moving object. The object creates a trigger as it passes a detector and the detector is placed such that the object will be in front of the camera 20 milliseconds after passing the detector. To freeze the action, a strobe light is set to fire with a 20 microsecond pulse when commanded by the camera. The camera is configured for a 4 millisecond exposure time and a hardware trigger with a trigger delay (see Section 5.1.3.11 on page 34) of 8 milliseconds. The GPO 1 control is set to strobe mode with a delay of 20 milliseconds to allow the sensor to fully reset before the flash fires. When the trigger arrives at the camera, the camera will wait for 8 milliseconds before commencing the fast reset of the sensor, which will be completed approximately 11 milliseconds later (19 milliseconds after the trigger event). GPO 1 will wait for 20 milliseconds after the trigger before it fires the flash. 4 milliseconds after the fast reset is complete, the readout begins and takes approximately 188 milliseconds to complete. The whole process from trigger to end of readout takes 211 milliseconds.

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3.3 Performance Specifications

The PL-A780 responds to visible light in the 400 – 1000 nm range. The chart of spectral response is shown in Figure 8 below.

Performance figures for FPN, PRNU and dynamic range are currently being measured. Accurate test data will be published as soon as it is available.

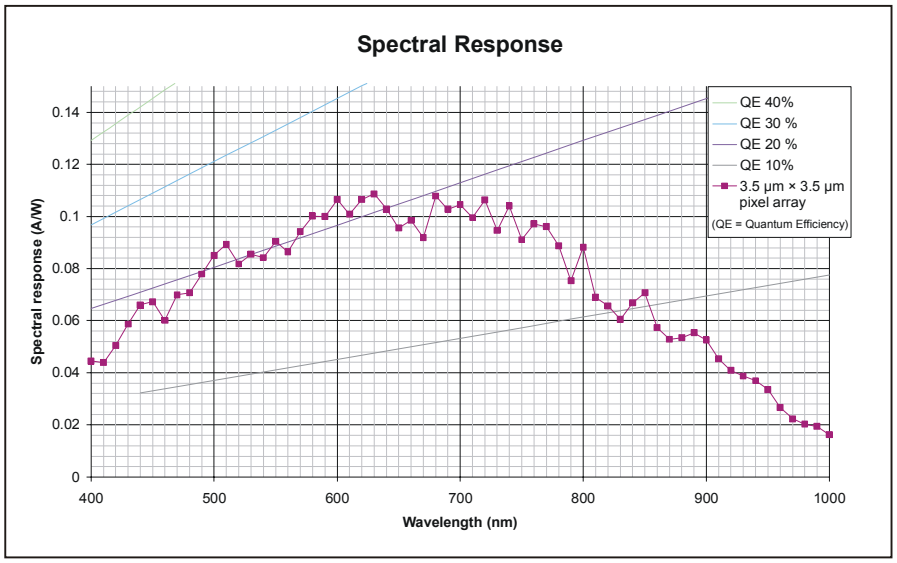

Figure 8 PL-A780 Spectral Response

3.4 Operating Environment

The PL-A780 camera is designed to operate in a dry industrial environment. The housing is machined from aluminum and provides a rigid mounting structure for the internal electronics. Vibration testing, temperature testing and EMC compatibility testing will all be completed in 2004. Check the PixeLINK web site for updates to this manual.

3.4.1 Operating Environment Objectives

Table 6 Operating Environment Conditions

Condition	Limits
Temperature	0°C to +45°C (32°F to 113°F)
Temperature change	< 10°C/minute (< 18°F/minute)
Shock	50 G
Vibration	10 G at 20-200 Hz
Humidity	20% - 80% non condensing

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3.4.2 Storage Environment Objectives

Table 7 Storage Environment Conditions

Condition	Limits
Temperature	-40°C to + 75°C (-40°F to 167°F)
Temperature change	< 10°C/minute (< 18°F/minute)
Shock	50 G
Vibration	10 G at 20-200 Hz
Humidity	20% - 80% non condensing

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4 Hardware Overview

4.1 PL-A780 Hardware Features

Hardware Features:

- 6.6 Megapixel imager resolution (2208 H x 3000 V)
- FireWire interface (two six-pin connectors)
- Machine Vision interface for external trigger and GPO (strobe)
- Lens mount for a standard C-mount lens (1" × 32 tpi) [lens not included]
- Front and bottom mounting holes for a tripod or other mounting fixture (M3 screws)

Accessories

Accessories such as trigger kits, tripod mounts, lenses, laptop accessory kits and hands-free switches are available from PixeLINK. For a current list of accessories, visit the PixeLINK Web site at http://www.pixelink.com/ or contact your PixeLINK vendor.

4.2 PL-A780 Hardware Dimensions

Measurements are ± 0.005 inches (0.15 mm).

Height..... 1.65 in /40.6 mm
Width..... 1.97 in/50 mm
Length..... 4.017 in/102 mm
Weight..... 7 oz/200 g (without lens)

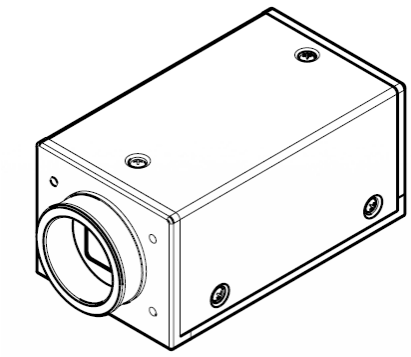

Figure 9 PL-A780 Standard Configuration

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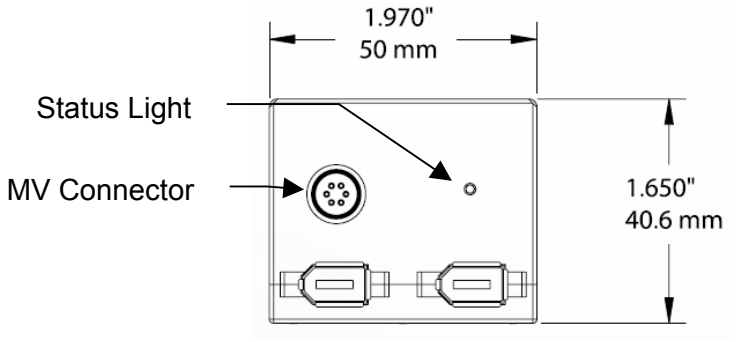

Figure 10 PL-A780 Rear View

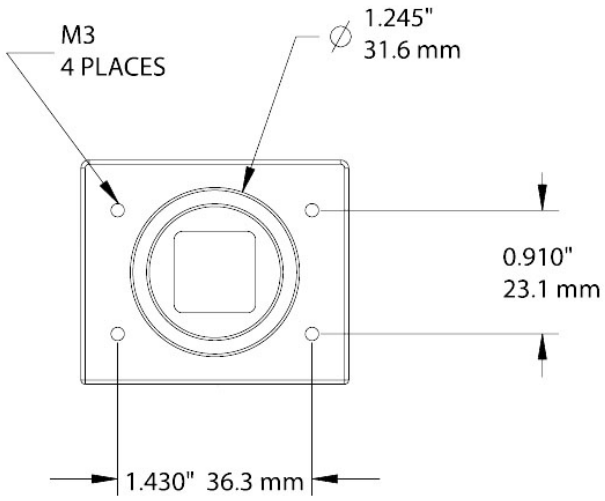

Figure 11 PL-A780 Front View

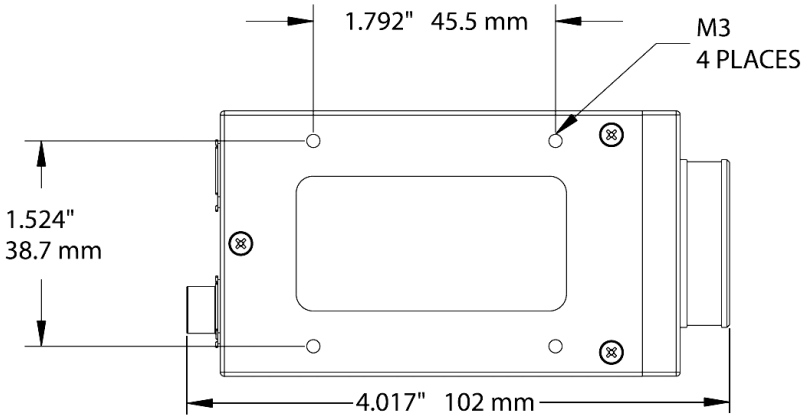

Figure 12 PL-A780 Bottom View

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4.3 PL-A780 Handling Instructions

Caution:

Do not open the camera housing.

ESD— Handle the PL-A780 using proper ESD procedures. Refer to ANSI/ESD S20.20 Class Type 3 (4000 V).

Cleaning

Housing: Clean the housing with a cloth dampened (not dripping) with reagent-grade isopropyl alcohol.

Glass: Clean the protective glass according to the instructions in Section 4.4.2.

4.4 Lens and Protective Glass

4.4.1 Lens

The Camera's C-mount fits a standard C-mount lens (1" × 32 tpi). A 1" lens is recommended.

4.4.2 Protective Glass

Each Camera is fitted with an IR cutoff filter to improve the color reproduction of the PL-A782 camera and protect the sensor. The PL-A781 monochrome camera is fitted with clear BK7 glass. The glass is not removable in the field.

Caution:

Removing the glass increases the likelihood of contaminating the image sensor. If the glass is not place, operate the camera under clean-room conditions only.

Cleaning the Glass:

Minor cleaning:

1. Carefully apply puffs of dry, compressed air to move particles off the center of the glass.
2. Remove oils with a swab moistened with reagent-grade isopropyl alcohol. The swab should be damp but not dripping.

Caution:

Do not use acetone to clean the glass.

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4.5 Mounting

Bottom Mount

As shown in Figure 12 on page 18 there are four M3 threaded holes on the bottom of the PL-A780 Camera. These holes can be used to attach the camera to an optional ¼-20 thread mounting plate (available from your PixeLINK vendor) or to mount the camera to a custom fixture.

Sensor-Face Mount

As shown in Figure 11 on page 18, there are four M3 threaded holes surrounding the C-mount. These holes can be used to mount the Camera to a custom fixture.

Thermal Considerations

The camera dissipates 5 W. Heat affects image quality and results in visible pixel noise. For optimal image quality and performance, consider heat dissipation when mounting the camera. The camera should be mounted on a metal plate or fixture using the mounting holes on the front or bottom surface. The plate should provide a conduction path to remove the heat from the camera body. The tripod mount accessory is not an adequate mounting plate for this purpose. Clearances for airflow will also help dissipate heat. The PL-A780 has an internal temperature sensor that can be used to determine if the heat dissipation is adequate. With good heat sinking, the sensor should be around 5º above the ambient temperature.

4.6 Electrical Connections

The PL-A782 Camera has the following connectors on the back, as shown in Figure 10 on page 18.

- 2 six-pin FireWire Connectors—Combined power, data, and control signals
- A six-pin Hirose connector—Trigger and strobe

4.6.1 FireWire – Power, Data & Control

The PL-A780 has two six-pin FireWire connectors (ports), allowing several devices to be daisy-chained. The FireWire cable carries image data, power and control signals.

The connectors are compatible with both regular and harness-type (latching) FireWire plugs.

You do not need to power down the computer to connect or disconnect a camera, nor do you need to reboot after this is done.

Single camera connection: The FireWire connectors are functionally identical. Either one of them can be used for a single connection. Do not make more than one connection between the camera and the computer—the equipment will not be able to communicate properly and the system can crash.

Multiple camera connections: When connecting multiple cameras, do not create a functional loop. The number of cameras that may be managed simultaneously depends on the total bandwidth and may be limited by power availability and the processing capabilities of the host computer.

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Power

The host computer can supply power to the camera via the FireWire bus if the computer has a six-pin FireWire connector and the total power demand on the bus does not exceed the bus capacity.

Other systems—such as laptop computers or those with several FireWire devices daisy-chained—require an external 12 V supply to power the camera. This external power supply must be connected to the FireWire bus. For information about laptop accessory kits that include external power supplies, contact your PixeLINK vendor.

Power Demand

A single PL-A780 draws 5 watts from the FireWire cable or 417 mA @ 12 V.

Power Limitations

The power capacity of the bus depends on the FireWire adapter card installed in the host computer. To comply with the FireWire specification, the adapter card may supply a maximum of 1.5 A per FireWire port. However, it is permissible for the card's limit to be lower than 1.5 A per port (say, 1.0 A). Note that many cards do not state their current limits.

In a multiple camera system, the current required per camera increases with each additional camera attached to the bus. Each additional camera causes the bus voltage to drop, so the current demand is increased to maintain a constant power draw of 5 W per camera.

Hence, most two-port FireWire adapter cards can be used to power two cameras simultaneously.

If the current demand exceeds the card capacity, the status lights on the cameras will switch off. The status light is located above the FireWire connectors as shown in Figure 10 on page 18.

4.6.2 Status LED

The PL-A780 has a Status LED that indicates the hardware and operational status of the camera. The LED indicates the following behavior:

- Flashing orange indicates that the camera is initializing.
- Solid orange indicates that the camera is loading the FFC parameters from memory. This process takes approximately 20 seconds.
- Solid green indicates that the camera is ready for operation.
- Flashing green indicates that the camera is performing a lengthy operation or is streaming video data.
- Flashing red indicates that the camera has issued a warning on the latest command received.
- Solid red indicates that the camera has experienced an unrecoverable error.

4.6.3 Machine Vision Connector - Trigger and GPOs

The PL-A780 is equipped with a 6-pin Hirose connector for external control of a trigger, strobe or pulse as shown in Figure 10 on page 18.

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The connector pinout is listed in Table 8 on page 23. The connector's interface schematic is shown in Figure 13 below. The mating plug for the connector is an **HR10A-7P-6P**, a 6-pin round plug connector with solder-cup pins for the cable wires.

The trigger inputs are designed to work with a floating differential signal which will supply between 5V and 12V across the trigger terminals. With the Trigger polarity set to Positive, a rising voltage will cause a trigger. A falling voltage will cause a trigger if the trigger polarity is negative.

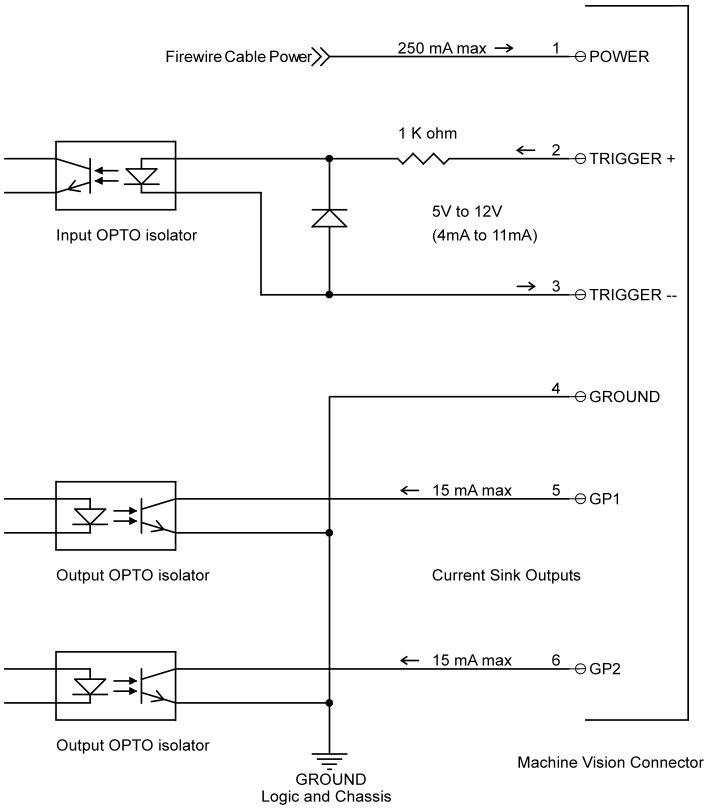

Figure 13 Machine Vision Connector—Interface Schematic

4.6.3.1 Trigger and GPO Timing

The default trigger latency on the PL-A780 cameras is 8 microseconds from the change in the trigger signal until the start of the image reset, assuming the Trigger Delay feature is set to zero. The start of integration will be delayed by the reset delay. This latency is due to:

- Optical-isolation delay on the trigger input (assume 5 V turn-on) = 6 µs typical;
- Debounce delay (5 MHz default) = 1.0 – 1.2 µs;
- Synchronization delay to start of reset = 0.5 µs; and
- Reset delay = 3.55 µs/row x N rows, where N is the number of rows, after decimation.

The trigger input can be either positive or negative pulse. The minimum pulse width depends on the debounce delay set in the camera – typically at least 50 microseconds for analog signals and at least 1 microsecond for TTL signals.

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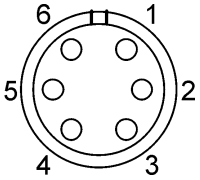
The debounce delay can be adjusted to allow for non-TTL signals to be used. To adjust the debounce delay for use with analog signals, use the Debounce Delay Adjustment Tool included with the PixeLINK software. A copy of the application is also available from the PixeLINK Web Site at http://www.pixelink.com. Look for the tool on the PL-A780 product page. The tool adjusts the clock frequency used to determine a valid trigger signal. The trigger detection circuit tests the value of the trigger at each clock tick and will only declare a trigger event when the trigger signal changes and remains constant for 5 clock cycles. By varying the clock frequency, the PL-A780 can use either analog trigger generators or digital TTL type signals. The clock frequency can be set at values ranging from 156 Hz to 10 MHz. For analog trigger sources, such as the Trigger Accessory included with the Developer's and Camera Kits, a clock setting of 100kHz or slower is required. For very clean digital triggers, the clock can be increased to the maximum 10 MHz. The camera is shipped with the clock set to 5 MHz.

Table 8 Pinout of the 6-Pin Hirose Connector



(Pinout as viewed on the back of the camera, or at the solder-end of the mating connector)

Pin	Pin Name	Function	Comments
1	POWER	FireWire cable power, 8–30 V DC (typically 12 V)	○ Maximum current available from this pin is 250 mA.
2	TRIGGER+	Positive terminal of optically isolated trigger input	○ To initiate a trigger, apply a voltage of between 5 V and 12 V (4–11 mA) to the trigger terminals. ○ The optically isolated trigger input circuit includes an internal 1 kΩ series resistor. ○ When using a voltage higher than 12 V, add an external resistor with adequate power rating. ○ A typical application of the trigger input is to connect Pin 1 (POWER) to Pin 2 (TRIGGER+) and use the open collector output of an external position sensor device to complete the circuit from Pin 3 (TRIGGER–) to Pin 4 (GROUND). ○ Timing: See Section 8.1 on page 54. ○ PixeLINK API--Refer to the functions *PxLSetFeature, PxLGetFeature*
3	TRIGGER–	Negative terminal of optically isolated trigger input	
4	GROUND	Logic and chassis ground	○
5	GP1	General Purpose Output (GPO) 1, for strobe	○ Open-collector current sink output from optical isolator. Provides current sink to Pin 4 (GROUND) when GP1/GP2 (as appropriate) is active. ○ Maximum current is 15 mA. ○ Timing: See Section 8.2 on page 55 ○ PixeLINK API--Refer to the functions *PxLSetFeature, PxLGetFeature*
6	GP2	General Purpose Output (GPO) 2, for strobe	

4.6.3.2 Trigger Connection Examples

The trigger inputs can accept floating signals that aren't tied to the camera ground.

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Using an analog trigger switch that connects to ground when a trigger occurs:

- Connect Pin 1 (Power) to Pin 2 (Trigger +)
- Connect trigger switch between Pin 3 (Trigger -) and Pin 4 (Ground)

More sophisticated examples using TTL logic are shown in Figure 14 and Figure 15 below. Figure 16 on page 25 shows an example using an optical trigger where the optical sensor is used to trigger multiple cameras. Note that with such a device, there will be some noise as the signal is switched and the camera's debounce clock should be reduced to 100KHz to avoid multiple triggers.

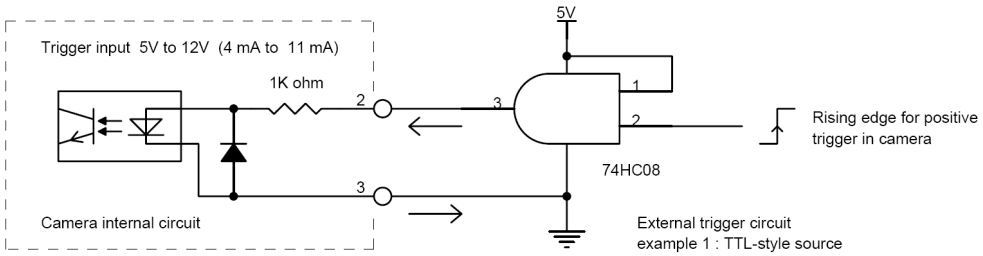

Figure 14 Trigger Input Example - TTL AND Gate

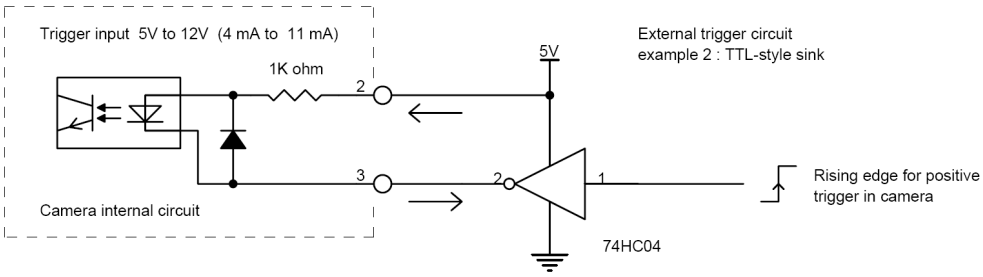

Figure 15 Trigger Input Example - TTL Inverter

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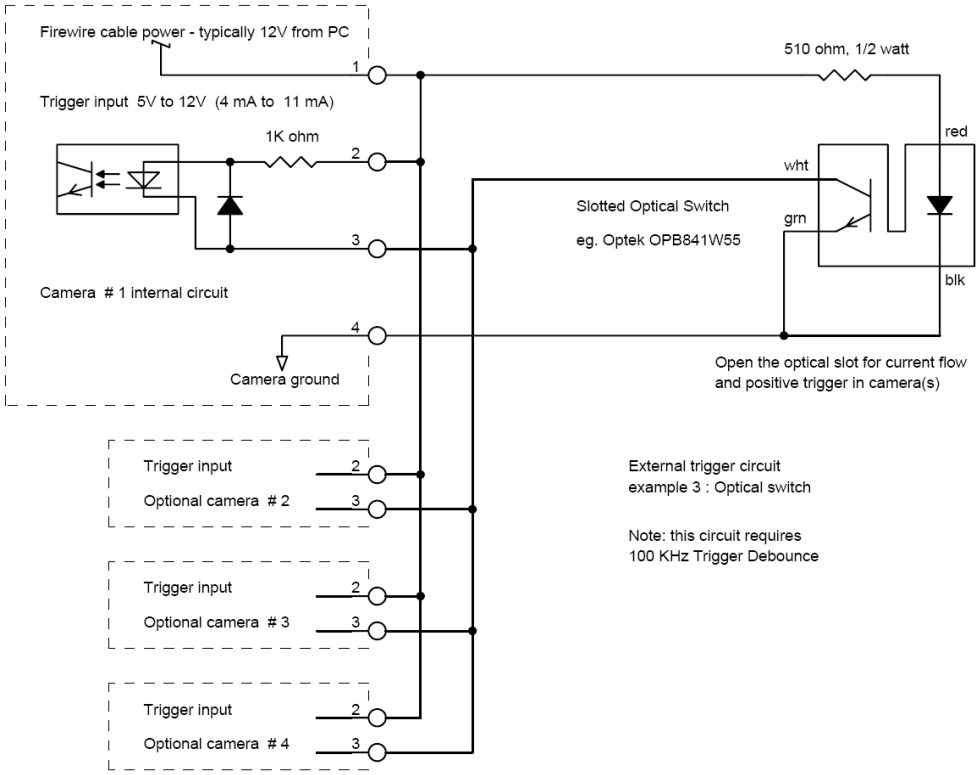

Figure 16 Trigger Input Example - An optical trigger and multiple cameras

4.6.3.3 GPO Connection Examples

The GPO pins are open-collector current sink outputs. To use them, the output line must be pulled high by the external circuit with a maximum current of 15 mA. Figure 17 below shows the GPO outputs from the camera being used to output a TTL signal. Figure 18 on page 26 shows the GPO from one camera being used to trigger a second camera.

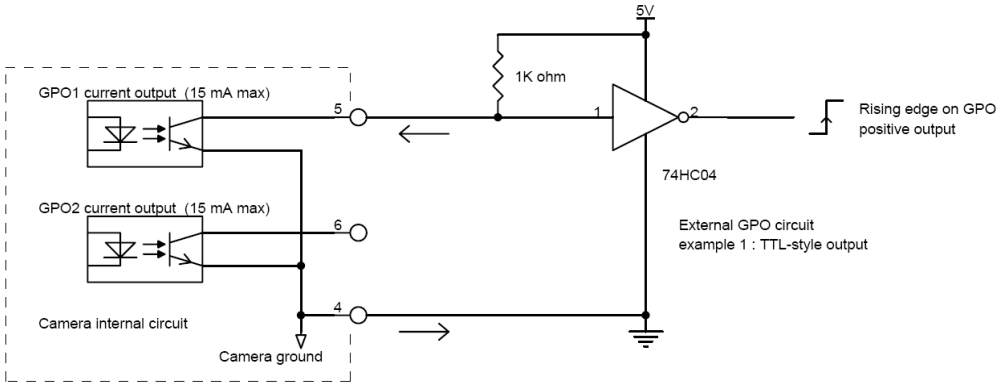

Figure 17 GPO Example - Output a TTL signal

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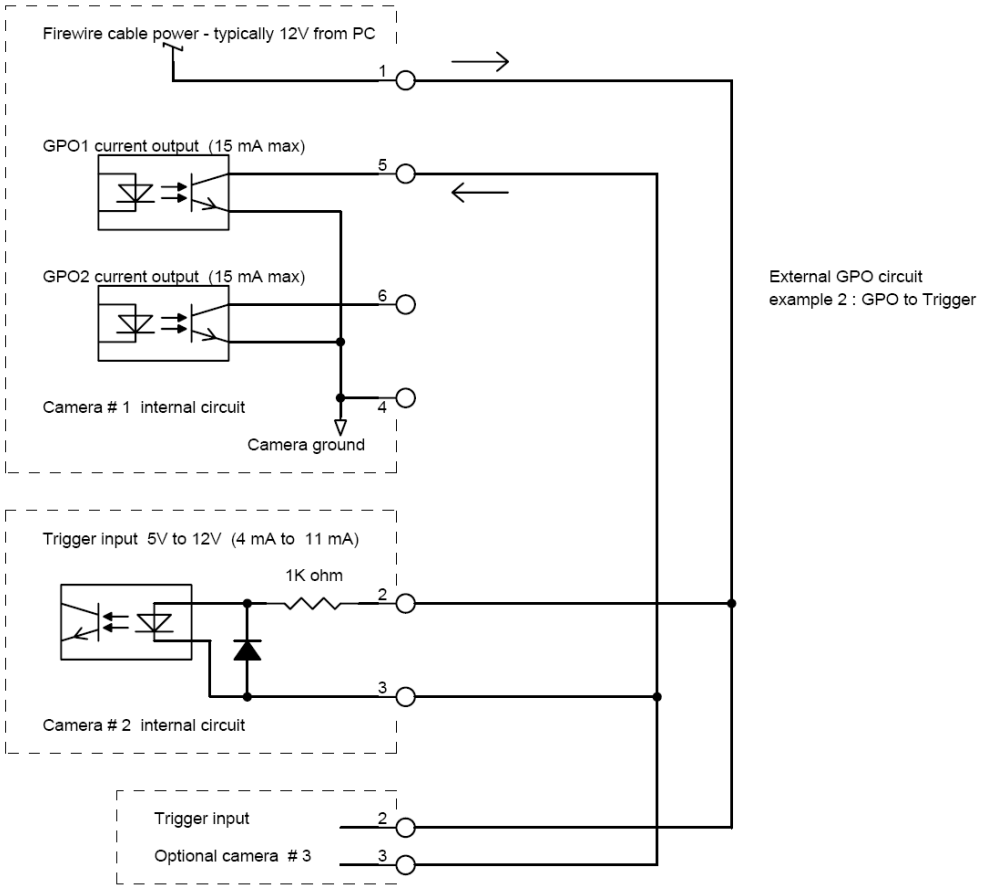

Figure 18 GPO Example - GPO to Trigger

4.6.3.4 Reading the Trigger Input

The raw value of the trigger input can be read from the IIDC Trigger Inquiry register. This can be used as a general purpose input if one is required.

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5 Camera Operation & Features

5.1 Supported IIDC 1.31 Features

The PL-A780 camera is IIDC 1.31 compliant. All registers and communications follow the IIDC 1.31 specification. Advanced Control and Status Registers (CSRs) are provided to support custom features.

This section describes the features and controls of the PL-A780 camera. For each feature, the set of values that define the feature in the IIDC specification are provided. In addition, information not included in the IIDC specification is provided to improve usability.

The camera supports all the features listed here. Any IIDC feature not listed is not supported. Features that are specific to a particular camera model are so indicated. The following information defines the feature:

- Auto – whether the feature can be controlled automatically. E.G. Auto exposure can maintain the correct exposure during changing illumination;
- Manual – whether the feature can be controlled manually. E.G. the Exposure is set to 10 ms;
- One-time Auto – whether the feature can be controlled automatically for a short period and then returned to manual mode. E.G. the exposure is set automatically for the current illumination settings and then fixed at that value;
- Off – whether the feature can be turned off;
- Change in Descriptors (CiD) – whether the feature settings can change between frames with descriptors;
- Parameters – whether the feature requires parameters. Each parameter has a name, unit of measure, and a type (relative or absolute);
- Min value;
- Max Value;
- Default; and
- Step size.

5.1.1 Camera Initialization

The PL-A780 camera can be initialized on command. On initialization, the camera will load the configuration parameters stored in Memory Channel 1. When the camera is delivered, the configuration in Memory Channel 1 matches the factory defaults in Memory Channel 0. Memory Channel 1 parameters can be set by the user so that the camera can be initialized to a user-defined state. This allows the camera to be configured on one system and then used on another computer without the need for camera configuration files on the two systems.

The camera can be initialized on command to the settings in Memory Channel 0 (factory defaults) or Memory Channel 1. See Section 5.1.3.5 on page 32 for more information.

The following table shows the factory default settings for the controllable camera features of the PL-A782.

Table 9 Default settings for PL-A780 features

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Feature	Default Value (PL-A782)
Color Coding	YUV422
Pixel Addressing	1 (No decimation)
Pixel Addressing Mode	0 (Decimate)
Frame Rate	Off
Gain	0db
Gain Blue	1.14db
Gain Green	1.0db
Gain Red	1.09db
Gamma	Off
GPO Mode	Mode 0 (Strobe)
GPO On	False (Off)
GPO Parameter 1	Min
GPO Parameter 2	Min
GPO Polarity	Positive
Programmable LUT	Linear
ROI Height	3000
ROI Left	0
ROI Top	0
ROI Width	2208
Saturation	100%
Shutter	100ms
Trigger Delay	0.0
Trigger Mode	0
Trigger Polarity	Positive
Trigger Source	Internal
Trigger Type	Fast Reset Shutter
Video Format	7
Video Frame Rate	Max Iso
Video Mode	0
White Balance	3200.0°

5.1.2 Video Format/Mode/Frame rate

The PL-A780 supports the following video formats, modes and frame rates.

- Format 0 VGA non-compressed 640 x 480
  - Mode 1, 320 x 240 YUV(4:2:2), Frame rate 2 to 4 (7.5 to 240 fps)
  - Mode 3, 640 x 480 YUV(4:2:2), Frame rate 2 to 7 (7.5 to 60 fps)
  - Mode 5, 640 x 480 Y (Mono) 8 bits/pixel, Frame rate 2 to 4 (7.5 to 60 fps)
  - Mode 6, 640 x 480 Y (Mono) 16 bits/pixel, Frame rate 2 to 4 (7.5 to 30 fps)
- Format 7 partial image size (variable ROI)

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Note that for Format 0 operation, the sensor ROI is set to 1920 x 1440 with the Pixel Addressing set to 3 or 6 for Modes 3 and 1 respectively. While in Format 0, the features that would affect the ROI size, position, Pixel Addressing and pixel format (color coding) are disabled.

5.1.3 IIDC Basic Features

The PL-A780 camera supports the following basic features:

- Color Coding (color versions only)
- Frame Rate
- Gain
- Gamma
- Memory Channel
- ROI
- Saturation (color versions only)
- Shutter
- Temperature
- Trigger
- Trigger Delay
- White Balance (color versions only)
- White Shading Compensation (color versions only)

Details about the registers and controls for these features can be found in the IIDC specification. The following sections provide a description of how the features apply to the PL-A780 camera, their parameters and limits.

Note that the IIDC specification allows two ways to control camera features. Feature values can be written into the feature control registers or into absolute value registers. The feature control registers are integer based and only allow positive integer values. The absolute value registers use floating point numbers and can represent engineering units. The PixeLINK PL-A780 camera will accept both methods of control. However, some third party software applications only use the feature control register values. As a result, the control sliders will have strange limits. For more information on the two types of registers, see Section 6.5.2 and Section 6.5.3 on page 44.

Table 10 below shows the minimum and maximum limits on the IIDC features that use feature control registers and the corresponding absolute value register values. Note that the absolute value registers may have different limits as outlined in the following sections.

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Table 10 Feature Control Register Min/Max Values.

Feature	Feature Control Register Values		Corresponding Absolute Values	
	Min	Max	Min	Max
Frame Rate	1	4000	2.0	8000.0
Gain	0	2210	0.0	22.1
Gamma	1	40	0.1	4.0
Saturation	0	250	0.0	250.0
Shutter	1	4095	0.0001	0.4095
Trigger Delay	0	2500	0.0	2.5
White Balance	320	500	3200	5000
White Shading	0	255	0.0	4.0

5.1.3.1 Frame Rate

Auto	No
Manual	Yes
One-time Auto	No
Off	Yes
CiD	No

The frame interval and the required bandwidth on the FireWire bus are fixed by the Frame Rate value. The available frame rate range depends on the current video format and/or video mode. Programmers are recommended to check the ON/OFF setting and minimum and maximum value after video format, ROI and/or video mode have been changed.

When the Frame Rate feature is ON, the exposure time (Shutter) is limited by the frame rate value dynamically. When the Frame Rate value is changed, the minimum and maximum limits on the Shutter control will change accordingly. The Shutter value will be forced to lie within these limits.

After a change to ROI, video format or video mode, the Frame Rate control will attempt to maintain the same frame rate. If this is not possible, the Frame Rate control will be turned OFF.

When the Frame Rate control is OFF, the frame rate value defaults to the maximum isochronous frame rate. The frame rate is then a function of the exposure time for exposures longer than the inverse of the frame rate value. For shorter exposure times, the frame rate will be constant.

The absolute maximum frame rate is achieved by using asynchronous communication on the FireWire bus. To set the maximum output frame rate, ensure the Frame Rate control is ON and set the control to its maximum value.

The minimum frame rate (maximum frame interval) in rolling shutter mode (See Section 3.2.3 on page 12) is determined by the ROI height (number of pixel rows). The equation below determines the maximum frame interval, in milliseconds, for a given ROI height.

$$MaxFrameInterval = 0.8192 * ROI\ Height$$

In Fast Reset Shutter mode (see Section 3.2.3 on page 12), the Frame Rate control can be used to control the bandwidth on the FireWire bus. The frame interval can be effectively controlled by the trigger or by adding delays to the internal trigger. The maximum internal delay is 2.5 seconds.

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Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Frame Rate	fps	Absolute	Varies from 2	Varies up to 8000	Max ISO	Varies	Step size varies with the number of rows in the image. It is essentially the readout time of one column.

5.1.3.2 Color Coding

The Color Coding feature selects the output type of the camera.

The PL-A782 supports the following types: 4:2:2 YUV (2), Raw8 (9) and Raw16 (10).

The PL-A781 (monochrome) supports Mono8 (0) and Mono16 (5).

Auto	No
Manual	Yes
One-time Auto	No
Off	No
CiD	No

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Color coding format	None	Absolute	N/A	N/A	N/A	N/A	

5.1.3.3 Gain

Gain, or contrast, controls the sensitivity of the camera. Increasing gain will increase the sensitivity but will also increase the noise in the image.

The Gain control can be set to one of seventeen values: 0.0, 1.6, 3.1, 4.8, 6.3, 7.8, 9.2, 10.6, 12.0, 13.4, 14.8, 16.2, 17.6, 19.2, 20.7, or 22.1 A setting of 0.0 represents the imager unity gain setting.

Auto	No
Manual	Yes
One-time Auto	No
Off	No
CiD	Yes

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Gain	dB	Relative	0	22.1	0	Non linear	

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5.1.3.4 Gamma

Gamma controls the contrast in the image by translating pixel values according to a logarithmic curve. A value of one is a linear translation. Higher or lower values of gamma will result in missing codes in the image histogram.

The Gamma curve is applied internally in the camera in the form of a calculated look up table – the same table used by the Look Up Table feature. When the Gamma feature is activated, the Look Up Table feature is disabled and vice versa.

Auto	No
Manual	Yes
One-time Auto	No
Off	Yes
CiD	No

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Gamma	None	Absolute	0.1	4.0	2.2	0.1	

5.1.3.5 Memory Channel

The memory channel feature stores all camera parameters into non-volatile memory. Valid values are 0 for factory defaults or 1 for memory channel 1.

Auto	No
Manual	Yes
One-time Auto	No
Off	No
CiD	No

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Memory Channel	None	Absolute	0	1	1	1	

5.1.3.6 Region of Interest

Under video format 7, the ROI control sets the area on the imager that is active. Together with the Pixel Addressing mode and the pixel format, the ROI control determines the total number of pixels in a frame and the total size of the image. The smallest ROI possible is 24 x 24 pixels. The ROI can be positioned with a granularity of 24 pixels in both horizontal and vertical directions.

Auto	No
Manual	Yes
One-time Auto	No
Off	No
CiD	Yes

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Left	Columns	Absolute	0	2184	0	24	
Top	Rows	Absolute	0	2976	0	24	
Width	Columns	Absolute	24	2208	2208	24	
Height	Rows	Absolute	24	3000	3000	24	

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5.1.3.7 Saturation

Saturation controls the intensity of the hues in the image. The saturation control allows the hue to be changed from full mono to twice the normal hue.

Saturation is applicable to color cameras only.

Auto	No
Manual	Yes
One-time Auto	No
Off	No
CiD	No

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Alpha	Percentage	Relative	0	250	100	1	

5.1.3.8 Shutter

Shutter controls the integration time of the sensor. The shutter can be controlled manually, once automatically or fully automatically. In the auto modes, the camera will attempt to set the shutter feature such that a small portion of the scene is saturated.

In rolling shutter mode (See the Trigger feature, Section 5.1.3.10 on page 34), the Shutter control determines the number of lines in the ROI that are active at any time. In Fast Reset Shutter mode, the Shutter control determines the length of time from the completion of frame reset to the start of readout.

When the Frame Rate control is active (ON), the Shutter control is limited by the Frame Rate control setting. For example, if the Frame Rate control is set to 50 fps, the maximum value of the Shutter control will be limited to 20 ms. For unlimited control of the Shutter feature, the Frame Rate control must be turned off.

Auto	Yes
Manual	Yes
One-time Auto	Yes
Off	No
CiD	Yes

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Integration Time	Seconds	Absolute	63 µs	2.0	0.1	Varies	The integration time step size is the time required to read out one row. See Section 3.2.3 on page 12.

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5.1.3.9 Temperature

The Temperature control is a read only control that provides an indication of the temperature of the sensor chip.

Auto	No
Manual	No
One-time Auto	No
Off	No
CiD	No

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Temperature	Deg. C.	Absolute	N/A	N/A	N/A	N/A	

5.1.3.10 Trigger

Trigger controls the response of the camera to an external trigger input. It also controls the rolling shutter or Fast Reset Shutter behavior of the camera. Trigger modes and parameters are described in detail in Section 8.1 on page 54. Turning the trigger off enables the rolling shutter. Turning the trigger on enables the Fast Reset Shutter.

Auto	No
Manual	Yes
One-time Auto	No
Off	Yes
CiD	Yes

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Mode	None	Absolute	0	0	0	0	The PL-A780 only supports Trigger Mode 0. See Section 8.1.
Source	None	Absolute	0	1	0	1	0: External, 1: Internal
Polarity	None	Absolute	0	1	0	1	0: Negative, 1:Positive
Delay	Seconds	Absolute	0	2.5	0	0.000001	Delay from trigger detection to start of integration.
Parameter 1	Varies. Depends on the Mode. See Section 8.1 on page 54.						

5.1.3.11 Trigger Delay

The Trigger Delay control adds a delay to start of integration from the detection of the internal or external trigger event. See Section 8.1 on page 54 for more information. Turning the trigger delay off disables the effects of the delay. This delay is in addition to trigger latency discussed in Section 4.6.3.1 on page 22. To adjust the trigger debounce delay, see Section 4.6.3.1 on page 22.

Auto	No
Manual	Yes
One-time Auto	No
Off	Yes
CiD	Yes

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Delay	Ms	Absolute	0	2.5	0	0.000001	See Section 8.1

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5.1.3.12 White Balance

Auto	No
Manual	Yes
One-time Auto	Yes
Off	Yes
CiD	No

White Balance defines the color temperature of the light source. The camera uses this information to select form one of a number of possible color correction matrices. Turning the White Balance off disables the color correction.

The PL-A782 has color correction settings for 3200ºK (incandescent) and 5000ºK (daylight). Minor variations in coloring can be adjusted with the White Shading feature described in the next section.

When the White Balance control is set in Auto Mode, it will control the White Shading feature. This allows for consistent use of Auto White Balance terminology.

Applies to color cameras only.

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
White Balance	Deg. Kelvin	Absolute	3200	5000	3200	1800	

5.1.3.13 White Shading

Auto	No
Manual	Yes
One-time Auto	Yes
Off	No
CiD	Yes

The White Shading feature provides control over the individual red, green and blue channel gains so that non-standard color balance can be achieved. One-push Auto will attempt to white balance the gains (match the histogram peaks of each color channel) based on the image data in the current ROI. The white shading control, as described in the IIDC 1.31 specification, only provides for 8 bits of shading data per channel. Additional CSRs are provided to allow 32-bit resolution in color channels. See Section 7.1.1.1 on page 52. The White Shading can also be set by the Auto mode of the White Balance control mentioned above.

Setting a gain parameter to zero will effectively turn off that color channel – it will output a zero value.

Applies to color cameras only.

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Gain Red	None	Absolute	0	4	1.42	0.0156	
Gain Green	None	Absolute	0	4	1.0	0.0156	
Gain Blue	None	Absolute	0	4	1.08	0.0156	

5.1.4 Advanced Features

The following features are not defined by the IIDC specification but are specific to PixeLINK cameras and to the PL-A780 camera series. To access, read and/or control these features, see Section 7.1 Extensions to the IIDC Version 1.31 Specification on page 52.

The advanced features include the following:

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- Camera Information
- Camera Name
- Descriptors
- General Purpose Outputs
- Look Up Table
- Pixel Addressing

5.1.4.1 Camera Information

A block of CSRs provides read only access to basic camera information including:

- Camera Serial Number
- FPGA Version
- Firmware Version
- Camera Description

The camera serial number is a factory set string of numbers that uniquely identifies the camera. The FPGA Version and Firmware Version identify the hardware and firmware versions currently loaded in the camera. The FPGA and Firmware can be updated in the field and these entries will reflect the versions currently loaded. The FPGA and Firmware version numbers are stored as a 32 bit word and can be decoded in the form Byte0.Byte1.Byte2.Byte3.

The camera description is a text string, up to 256 characters long, that provides a short description of the camera type.

5.1.4.2 Camera Name

The name of the camera can be read and set from this feature. It is a text string of up to 256 characters in length.

5.1.4.3 Descriptors

A descriptor is a list of all the camera parameters. The Descriptor feature is a way to control camera settings between frames without communication between the host computer and the camera. This allows for rapid changes of camera parameters in a deterministic manner. When in rolling shutter mode, if the changes affect the sensor, the camera will drop a frame and send the next one, effectively halving the frame rate.

Descriptors also provide information about the current camera settings. Most of the camera settings will be known to the host computer but a few, especially the features that are set to Auto, may change without the host's knowledge. The descriptor structure is set up in two parts so that all the settings that can change are in the first part and all the known and static settings are in the second. The complete descriptor can be written or read from camera memory. It is important to check the version of the descriptor structure in order to use the correct structure.

The first part of the descriptor structure is always appended to each frame. For more information on the manner and format in which the data is appended to the frame, refer to Section 9 on page 56.

For camera control, up to 14 descriptors can be created and stored in camera memory. The camera will apply each descriptor in turn when capturing images. When multiple descriptors are in use, the camera will encode a synchronization number in the first 16 bytes of image

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data returned from the camera. The format of the synchronization code is shown in Section 9 on page 56.

Descriptors are created by increasing the number of descriptors in the descriptor configuration CSR. A new descriptor will have the same values as the current descriptor or, if it is the first descriptor created, the camera settings. With more than one descriptor, the camera will cycle through the descriptors repetitively.

Descriptors can be changed by updating the descriptor values in camera memory.

To delete a descriptor, reduce the number of descriptors in the descriptor configuration CSR. The highest indexed descriptors will be deleted first.

For more information on the descriptor structures, refer to Section 9.2 on page 57.

5.1.4.4 General Purpose Outputs

General Purpose Output (GPO) signals are controlled by this feature. The output signal is defined by a mode, polarity and a number of parameters that vary in meaning with the mode. For a complete description of the PL-A780 GPO modes and settings, see Section 8.2.

Auto	No
Manual	Yes
One-time Auto	No
Off	Yes
CiD	Yes

4 GPO signals can be controlled. GPO numbers 1 and 2 are available externally. 3 and 4 are only available on the board-level variant of the PL-A780.

Applies to PL-A780 cameras only.

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Mode	None	Absolute	0	4	0	1	
Polarity	None	Absolute	0	1	0	1	0: Negative, 1: Positive
Parameter 1	See Section 8.2 for details.						
Parameter 2							
Parameter 3							

5.1.4.5 Look Up Table

In the PL-A780, the Look Up Table (LUT) has 1024 2-byte entries that range in value from 0 to 1023 (10-bit depth). The LUT is used to implement the IIDC Gamma feature but it can also be used to implement any LUT transfer function required.

The LUT is written to camera memory as a block of 1024 words at the address specified by the Look Up Table Offset register, starting with Word 0 (Black).

When the LUT or Gamma function is active (ON), every pixel is converted according to the transfer function stored in the LUT. With both functions off, the LUT is bypassed and a linear transfer function is used.

Since both Gamma and the LUT use the same camera memory, whichever function was last turned on will control the memory and the other function will be turned off. Turning on the Gamma function will overwrite the LUT with the appropriate gamma values.

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Turning on the LUT will disable Gamma but will leave the camera memory unchanged. If the LUT is turned off, the LUT values will be retained in camera memory and will be applied again once the LUT is turned on.

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5.1.4.6 Pixel Addressing

Auto	No
Manual	Yes
One-time Auto	No
Off	Yes
CiD	No

The Pixel Addressing feature controls the number of pixels that are read from the ROI. See Section 3.2.1 on page 7 for more information.

Pixel Addressing is controlled by two parameters – a Pixel Addressing mode and a value. The mode of Pixel Addressing can be decimate (0), averaging (1), binning (2) or resampling (3). The Pixel Addressing value can be one of 1, 2, 3, 4 or 6.

With a Pixel Addressing value of 1, the Pixel Addressing mode has no effect and all pixels in the ROI will be returned. For Pixel Addressing values greater than 1, the number of pixels will be reduced by the square of the value. For example, a Pixel Addressing value of 2 will result in ¼ of the pixels.

The Pixel Addressing mode determines how the number of pixels is reduced. The Pixel Addressing value can be considered as the size of a block of pixels made up of 2x2 groups. For example, a Pixel Addressing value of 3 will reduce a 6 x 6 block of pixels to a 2 x 2 block – a reduction of 4/36 or 1/9.

The decimate mode will drop pixels all the pixels in the block except for the top-left group of four. This creates the 2x2 blocks of pixels shown in Figure 2 to Figure 5 on page 8. At the highest Pixel Addressing value of 6, a 12 x 12 block of pixels is reduced to 2 x 2. At this level of reduction detail in the scene can be lost and color artifacts introduced.

The averaging mode will average pixels with the similar color within the block resulting in a 2x2 Bayer pattern. This allows details in the blocks to be detected and reduces the effects of the color artifacts.

The binning mode will sum pixels with similar color within the block reducing the block to a 2x2 Bayer pattern. Unlike binning with CCD sensors, this summation occurs after the image is digitized so no increase in sensitivity will be noticed but a dark image will appear brighter.

The resampling mode uses a different approach involving the conversion of the Bayer pattern in the blocks to RGB pixels. With a Pixel Addressing value of 1, resampling has no effect. With a Pixel Addressing mode of 2 or more, resampling will convert the block of 10-bit pixels to one 30-bit RGB pixel by averaging the red, green and blue channels. The 30-bit RGB value is output from the camera when the video format is set to Y:U:V mode. Resampling will create images with the highest quality and the least artifacts.

Pixel Addressing will reduce the amount of data coming from the camera. However, only the Decimate mode will permit an increase in the frame rate. Averaging, binning and resampling modes will have the same frame rate as if the Pixel Addressing value was 1 (no decimation.)

Pixel Addressing works in the same fashion with color or monochrome sensors.

Parameter	Unit	Type	Min	Max	Default	Step Size	Comments
Mode	None	Absolute	0	3	0	1	0: Decimate, 1: Average, 2: Bin, 3: Resample
Value	None	Absolute	1	6	1	1	Pixel Addressing Value of 5 is not supported.

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5.2 Non IIDC Features Accessible with the PixeLINK API

The following features are specific to the PL-A780 camera series. To access them, you will need the PixeLINK Software Development Kit (PL-SDK-VERSION-4.1).

The PixeLINK API defines two functions that allow access to camera specific features. These are PxLCameraRead and PxLCameraWrite. They can be used with the PL-A78X to turn on or off flat field correction and determine what gain the camera was calibrated at.

5.2.1 Flat Field Correction

Flat Field Correction (FFC) applies a gain and offset correction per pixel to correct for illumination and sensor irregularities. A factory calibration is performed and stored in the camera memory. It is possible to perform FFC calibration in the field using a software tool available with the CD that ships with –KIT and –DEV product bundles or from the PixeLINK web site. Look for downloads associated with the PL-A781 or PL-A782 products. See Section 1on page 1 for more information.

The data to transmit for flat field correction has in the following format:

```
struct
    {
        ULONG CommandCode;

        ULONG FfcOn;                  // 1 = On, 0 = OFF
        FLOAT FfcCalibrationGain;     // Gain at which FFC was
                                       // calibrated in dB
    };
```

To turn flat field correction off or on, set FfcOn to 0 or 1 and CommandCode to 0x00008002.

To read the flat field correction settings set CommandCode to 0x00008001.

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6 Developing Software for the PL-A780

The purpose of this section is to give the reader a basic introduction to the IIDC (Digital Camera) v1.31 specification and to provide a basic description of how software could be written to communicate with an IIDC compliant camera.

To make use of the information presented here, please refer to the following related documentation:

IIDC 1394-based Digital Camera Specification (Version 1.31)
IEEE 1394-1995 Serial Bus Specification
IEEE 1394a Supplement
CSR Architecture Specification – ISO/IEC 13212 (ANSI/IEEE 1212)

If you are using the PixeLINK SDK, you do not need to read this section. The PixeLINK SDK is a high level Application Programming Interface (API) compatible with C, C++ and Visual Basic. It provides low-level drivers and a high-level software interface to the camera that simplifies the task of controlling PixeLINK cameras. Details on the API functions can be found in the PixeLINK API Reference Manual.

6.1 Introduction

The IIDC Specification was written to act as a design guide for digital camera makers wishing to have cameras that would be interoperable across many different software applications and systems. As a result it is fairly technical and assumes familiarity with 1394 and the control and status register architecture. This does not make it well suited for developers with little or no 1394 experience who wish to understand how software communicates with an IIDC compliant camera. There are also several sections in the specification that are vague enough that they could be interpreted in several ways. This section will provide an overview of IIDC and help in interpreting the IIDC specification.

6.2 Useful Definitions

- *CSR* – Control and Status Register – A 4 byte control register used in 1394 devices.
- *Quadlet* – A 4 byte value
- *Configuration ROM* – A portion of a 1394 device's address space that contains configuration information about the device.
- *Bus Info Block* – A portion of a 1394 device's *Configuration ROM* that specifies a variety of bus related capabilities.
- *Root Directory* – A portion of a 1394 device's *Configuration ROM* that provides information necessary for the device to be identified along with pointers to other directories and data structures.
- *Unit Directory* – A portion of a 1394 device's *Configuration ROM* that provides information about a specific function of the device.
- *Quadlet Offset* – This term is used throughout the IIDC specification and means the number of *Quadlets* from a specified base address. (I.e. if a quadlet offset is determined to be 100h then the actual address offset would be 400h).
- *IIDC Base Address* – The base address of the IIDC address space to which *CSRs* in the IIDC specification refer.

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6.3 How Do 1394 Devices Communicate?

Essentially the IEEE - 1394 FireWire bus uses a memory mapped communication protocol. 1394 transactions can be considered to be a read or write of data to a specified memory address. 1394 uses 64bits of addressing: 16 bits for bus and node addressing with each node (or device) on the bus having 48 bits of address space. The IIDC specification defines how the address space on an IIDC compliant camera is implemented.

NOTE: 1394 uses big-endian notation, that means that the most significant byte comes first and the most significant bit is bit 0. The PC uses little endian notation, where the least significant byte comes first.

6.4 Communication With a IIDC Camera

In order to begin communication with an IIDC camera it is first necessary to determine in which portion of the address space the IIDC camera is located. To allow flexibility in device implementation the IIDC address space is not the same between devices but can be selected by the camera manufacturer.

The IIDC specification defines the base address of the IIDC address space as **FFFF Fxxx xxxh** where the **xxx xxxxh** is determined from the camera's *Configuration ROM*.

6.4.1 Navigating the Configuration ROM

The IIDC specification defines the format of the *Configuration ROM* for IIDC cameras. The offsets listed in the *Root Directory* table are all relative to the base address **FFFF F000 0000h**.

To determine the location of the *Unit Directory* the **unit_directory_offset** field must be read from offset **0424h** (or address **FFFF F000 0424h**). This field consists of an identifying key and a relative *quadlet offset*. The identifying key is an 8 bit value that for the unit directory offset is **D1h**. So if the value in the **unit_directory_offset** field is **D100 0004h** then the offset for the *unit directory* is 0424h + 4*04h = **0434h** (or address **FFFF F000 0434h**).

To determine the location of the Unit Dependent Directory the **unit_dependent_directory_offset** field must be read from offset **000Ch** of the *Unit Directory* (or address **FFFF F000 0440h** using the above example unit directory offset). The identifying key for the unit dependent directory offset is **D4h**. So if the value in the **unit_dependent_directory_offset** field is **D400 0001h** then the offset for the unit dependent directory is 0440h + 04h = **0444h** (or address **FFFF F000 0444h**).

The Unit Dependent Directory contains, among other things, the *IIDC Base Address*, which can be read from the **command_regs_base** field of the Unit Dependent Directory. The identifying key for the **command_regs_base** field is **40h**. So if the value of that field is **4034 0000h** then the offset of the IIDC address space is **00D0 0000h** or the *IIDC Base Address* is **FFFF F0D0 0000h**.

NOTE: This sample *IIDC Base Address* will be used in all further examples in this document.

6.4.2 IIDC Command Registers

In Section 1 of the IIDC specification all Command registers (or CSRs) are defined. The offsets for all of these registers, unless otherwise specified, are relative to the *IIDC Base Address*. The IIDC CSRs consist of Inquiry Registers and Control Registers. The IIDC specification is designed to support many different types of cameras with many different features, the Inquiry registers are used by controlling software to determine which of these

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features a specific camera supports and the Control registers are used to modify settings of the supported features. The next section will go into more detail about some of these registers.

6.5 Command Register Details

This section will give details on some of the different IIDC command registers, what they mean and how to use them.

6.5.1 Video Formats

IIDC video formats are used to define what type of video data will be output from the camera. Several different formats are defined based on image size:

- Format 0 – VGA (640x480) and smaller resolutions
- Format 1 – SVGA format 1 (from 800x600 to 1024x768)
- Format 2 – SVGA format 2 (from 1280x960 to 1600x1200)
- Format 6 – Still Images (not described in this document)
- Format 7 – Scalable image size (user defined size and position)

For each video format there are several defined modes. The mode specifies the exact size of the video data and the size and color information of the pixels (i.e. Mono 8-bit, YUV422 16-bit, etc.)

A given camera will only support some of the video formats and some of the modes for the supported video formats. One of the first things controlling software should do is determine which formats and modes are supported.

The IIDC specification defines the Inquiry Registry for Video Format. This register can be read from offset **0100h** (or address **FFFF F0D0 0100h** using the example IIDC base address) and the value will indicate which formats are supported.

The IIDC specification defines the Inquiry Registers for Video Modes. There is a register for each video format. If format 1 is supported then the register at offset **0184h** (or address **FFFF F0D0 0184h**) can be read to determine which modes are supported for format 1.

6.5.1.1 Formats 0, 1 & 2

For formats 0, 1 & 2 there are also pre-defined frame rates for each video mode. The IIDC specification defines the Inquiry Registers for Video Frame Rates. There is a separate register for each video mode. Read the registers for the supported video modes to determine which frame rates the camera supports.

6.5.1.2 Format 7

Format 7 is very flexible, allowing the user to specify the width, height, position and pixel format of the video data. A separate set of control registers exists for each format 7 mode. To determine the location of these control registers for a given mode the offset can be read from registers starting at offset **02E0h**. For example, to determine the control register offset for format 7 mode 0 read the register at offset **01E0h** (or address **FFFF F0D0 01E0h**), if this value was **0034 0280h** then the offset for the control registers would be **00D0 0A00h** (or address **FFFF F0D0 0A00h**). Note that this offset is relative to the base address **FFFF F000 0000h** not the IIDC base address.

The format 7 control registers, as defined in the IIDC specification are mostly self-explanatory. They provide information on the sizes and positions of video data supported, the

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different types of pixel format supported, and provide controls to set all of these options. The also provide information and control of isochronous streaming parameters (discussed later in Section 6.6.2 on page 45).

For example to determine the current image width and height of the video data read the register at offset **000Ch** (or address **FFFF F0D0 0A0Ch** using the example format 7 mode 0 control register offset). If this value is **0500 0400h** then the current width and height would be 1280 x 1024.

6.5.2 Camera Features

The camera features are used to control different functions of the camera, from things like saturation and gamma to zoom and focus. A given camera will only support some of the defined features so controlling software needs to determine which features are supported. The IIDC specification defines the Inquiry Registers for feature presence. The values of these registers will indicate which features are supported.

There are also separate inquiry registers for each feature defined in the IIDC specification. The value of these registers will provide information about how the specific supported feature can be controlled including: the minimum and maximum value of the feature, if the feature can be controlled by the user (Manual_Inq), if the feature's value can be adjusted continuously by the camera (Auto_Inq), if the feature's value can be adjusted once automatically by the camera (One_Push_Inq), if the feature can be turned on and off (On/Off_Inq) and if the feature can be controlled with its Absolute Value register (see Section 6.5.3 below).

A supported feature can be controlled through it's control register. The registers allow controlling software to set the value or change the mode of the feature.

6.5.3 Absolute Value CSRs

There can be a set of absolute value registers for each supported camera feature. The absolute value registers allow for manual control of the feature using 32-bit IEEE floating point values. This allows for exact values using engineering units instead of arbitrary values (units for the absolute value registers are defined in Appendix B of the IIDC specification). The IIDC specification defines the Absolute Value CSRs. Each set of absolute value CSRs consist of three registers, a minimum value, a maximum value (both read only) and the current value. The IIDC specification defines the offsets of the Absolute Value CSRs for each of the camera features.

For example, to determine the location of the absolute value CSRs for the Brightness feature read the register at offset **0700h** (or address **FFFF F0D0 0700h**). If the value of this register was **0034 0380h** then the absolute value CSRs for Brightness would be located at offset **00D0 0E00h** (or address **FFFF F0D0 0E00h**), note that this offset is relative to the base address **FFFF F000 0000h** not the IIDC base address. If the values at offsets **0E00h**, **0E04h**, and **0E08h** were **0000 0000h**, **4000 0000h**, and **3F80 0000h** respectively then the min value would be 0.0, the max would be 2.0 and the current value would be 1.0.

6.5.4 Advanced Feature CSRs

Some camera vendors may wish to implement features that are not defined by the IIDC specification. This is done through the advanced feature register space. The IIDC specification defines the Inquiry Register for Basic Functions which indicates if the camera supports these vendor defined features. If they are supported then the offset for the

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advanced feature registers space is defined at offset **0480h** (Note that this offset is relative to the base address **FFFF F000 0000h** not the IIDC base address).

To be useful, the definition of the advanced features has to be supplied by the camera vendor in a form similar to this document.

6.6 Video Transmission Details

This section will give details on different ways to tell an IIDC camera to send video data, the way the data is transmitted and the format of the data.

6.6.1 Video Transmission Control

The IIDC Specification defines the general Status and Control Registers for the camera. Some of these registers are used to control the isochronous transmission of video data. The camera can either be setup to continuously output video frames, output a single frame, or output several frames.

6.6.2 Isochronous Packet Size

The camera controller must know the size of the isochronous packets that will be transmitted so that 1394 isochronous bandwidth can be allocated before instructing the camera to output data. In formats 0, 1 and 2 the packet size can be determined based on the mode and frame rate by consulting the appropriate table in the IIDC specification.

The packet size for format 7 can be determined from the format 7 control registers. These registers will also provide the number of bytes per frame and the number of packets per frame. Note that the packet size times the number of packets per frame may be greater than the number of bytes per frame, the extra bytes may be used for padding in the last packet of a frame and should be ignored.

6.6.3 Features That Affect Isochronous Packet Size or Format

The following list includes standard IIDC registers as well as PixeLINK extended registers:

Status and Control Registers
CUR_V_FRM_RATE
CUR_V_MODE
CUR_V_FORMAT
ISO_SPEED
Feature Status and Control Registers
FRAME_RATE
Format 7 Registers
IMAGE_SIZE
COLOR_CODING_ID
BYTE_PER_PACKET
Extended Registers
PIXEL ADDRESSING
DESCRIPTOR

When any of these registers are written to, ISO_EN, ONE_SHOT and MULTI_SHOT should all be set to 0. Otherwise the written values will be ignored and an error will be returned.

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7 PixeLINK Advanced CSRs

Information in this section is based on the IIDC 1.31 specification. Please refer to the IIDC 1.31 specification for details on the meanings and use of CSRs.

The following table describes the Advanced Feature CSRs that are allowed under the IIDC V1.31 specification as vendor specific. These CSRs are based at an offset found in the Advanced Feature Offset value (register 0x480).

This table is common for all IIDC compliant PixeLINK cameras and is included to promote compatibility. **Not all the features listed in this table are available with the PixeLINK PL-A780 cameras.** Check the presence bit of the inquiry register to determine if the feature is supported on a particular camera.

Table 11 Advanced Feature CSRs

Offset	Name	Field	Bit	Description
000h 004h	ACR		[0..63]	Advanced Feature Access Control Register (See NOTE 1)
CAMERA INFO REGISTERS (READ ONLY)				
008h	Serial Number Offset	Value	[0..31]	Quadlet offset of the Serial Number string from the base address of the initial register space
00Ch	Serial Number Length	Value	[0..31]	Length in bytes of the Serial Number string
010h	FPGA Version	Value	[0..31]	FPGA Version in format Byte0.Byte1.Byte2.Byte3
014h	FW Version	Value	[0..31]	Firmware Version in format Byte0.Byte1.Byte2.Byte3
018h	Camera Description Offset	Value	[0..31]	Quadlet offset of the Camera Description string from the base address of the initial register space (See NOTE 2)
01Ch	Camera Description Length	Value	[0..31]	Length in bytes of the Camera Description string
020h .. 0FCh	Reserved for future Camera Info registers.			
ADVANCED FEATURE INQUIRY REGISTERS (READ ONLY)				
100h	Name Inquiry	Presence_Inq	[0]	Presence of this feature
			[1..15]	Reserved
		Max_Length	[16..31]	Maximum length of Camera Name in bytes
104h	Name Offset	Value	[0..31]	Quadlet offset of the Camera Name string from the base address of the initial register space (See NOTE 2)
108h	Name Length	Value	[0..31]	Length in bytes of the Camera Name string (Read Only)

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Offset	Name	Field	Bit	Description
10Ch	Descriptor Inquiry	Presence_Inq	[0]	Presence of this feature
			[1..7]	Reserved
		Max_Num	[8..15]	Maximum number of Descriptors
		Struct_Ver	[16..31]	Version of the Descriptor Structure.
110h	Descriptor Offset	Value	[0..31]	Quadlet offset of the Descriptor Structure from the base address of the initial register space (See NOTE 2)
114h	Pixel Addressing Inquiry	Presence_Inq	[0]	Presence of this feature
		In_Desc_Inq	[1]	Can this feature have different values in different descriptors 1 = Yes, 0 = No
			[2..3]	Reserved
		Mode0_Inq	[4]	Presence of Pixel Addressing Mode 0 (e.g. decimation)
		Mode1_Inq	[5]	Presence of Pixel Addressing Mode 1 (e.g. averaging)
		Mode2_Inq	[6]	Presence of Pixel Addressing Mode 2 (e.g. binning)
		Mode3_Inq	[7]	Presence of Pixel Addressing Mode 3 (e.g. resampling)
		Base	[8..15]	Base for Pixel Addressing. Maximum Pixel Addressing is Base^Max_Value (except when Base = 1 then it is Max_Value)
		Max_Value	[16..31]	The maximum value for the Pixel Addressing variable
118h	Absolute Frame Rate	Offset	[0..31]	OBSOLETE. This has been replaced with the frame_rate feature in IIDC v1.31
11Ch	Flip Inquiry	H_Pres_Inq	[0]	Presence of Horizontal Flip
		In_Desc_Inq	[1]	Can Horizontal Flip have different values in different descriptors 1 = Yes, 0 = No
			[2..15]	Reserved
		V_Pres_Inq	[16]	Presence of Vertical Flip
		In_Desc_Inq	[17]	Can Vertical Flip have different values in different descriptors 1 = Yes, 0 = No
			[18..31]	Reserved
120h	Advanced Trigger Inquiry	Presence_Inq	[0]	OBSOLETE. This has been replaced with the trigger_source parameter of the trigger_mode feature in IIDC v1.31
		In_Desc_Inq	[1]	
			[2..7]	
		Trig_Intern_Inq	[8]	
		Trig_Type_Inq	[9]	
			[10..31]	

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Offset	Name	Field	Bit	Description
124h	Trigger Delay Offset	Offset	[0..31]	OBSOLETE. This has been replaced with the trigger_delay feature in IIDC v1.31
128h	General Purpose Output Inquiry	Presence_Inq	[0]	Presence of this feature
		In_Desc_Inq	[1]	Can this feature have different values in different descriptors 1 = Yes, 0 = No
			[2..3]	Reserved
		Number	[4..7]	Number of GPO lines (1-15)
		Mode0_Inq	[8]	Presence of GPO Mode 0
		Mode1_Inq	[9]	Presence of GPO Mode 1
		Mode2_Inq	[10]	Presence of GPO Mode 2
		Mode3_Inq	[11]	Presence of GPO Mode 3
		Mode4_Inq	[12]	Presence of GPO Mode 4
		Mode5_Inq	[13]	Presence of GPO Mode 5
		Mode6_Inq	[14]	Presence of GPO Mode 6
		Mode7_Inq	[15]	Presence of GPO Mode 7
		Mode8_Inq	[16]	Presence of GPO Mode 8
		Mode9_Inq	[17]	Presence of GPO Mode 9
		Mode10_Inq	[18]	Presence of GPO Mode 10
		Mode11_Inq	[19]	Presence of GPO Mode 11
		Mode12_Inq	[20]	Presence of GPO Mode 12
		Mode13_Inq	[21]	Presence of GPO Mode 13
		Mode14_Inq	[22]	Presence of GPO Mode 14
		Mode15_Inq	[23]	Presence of GPO Mode 15
			[24..31]	Reserved
12Ch	GPO Parameter 1	Offset	[0..31]	Quadlet offset of the absolute value CSR for GPO 0 Parameter 1 (See NOTE 3)
130h	GPO Parameter 2	Offset	[0..31]	Quadlet offset of the absolute value CSR for GPO 0 Parameter 2 (See NOTE 3)
134h	GPO Parameter 3	Offset	[0..31]	Quadlet offset of the absolute value CSR for GPO 0 Parameter 3 (See NOTE 3)
138h	Extended Shutter Inquiry	Presence_Inq	[0]	Presence of this feature
		In_Desc_Inq	[1]	Can this feature have different values in different descriptors 1 = Yes, 0 = No
			[2..3]	Reserved
		Number_Knees	[4..7]	Maximum Number of Knee Points (1-4)
			[8..31]	Reserved
13Ch	Extended Shutter Knee Point 0	Offset	[0..31]	Quadlet offset of the absolute value CSR for Extended Shutter Knee Point 0 (See NOTE 4)

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Offset	Name	Field	Bit	Description
140h	Lookup Tables Inquiry	Presence_Inq	[0]	Presence of this feature
		In_Desc_Inq	[1]	Can this feature have different values in different descriptors 1 = Yes, 0 = No
			[2..7]	Reserved
		Bit_Depth	[8..15]	Bit depth of an entry in the lookup table
		Number	[16..31]	Number of entries in the lookup table
144h	Look Up Table	Offset	[0..31]	Quadlet offset of the first entry in the lookup table. Each entry occupies a whole number of bytes (e.g. a 10bit entry occupies 2 bytes). The table must be written to in order, starting from byte 0.
148h	Auto ROI Inquiry	Presence_Inq	[0]	Presence of this feature
		In_Desc_Inq	[1]	Can this feature have different values in different descriptors 1 = Yes, 0 = No
			[2..7]	Reserved
		Invalid_ROI	[8]	0 = Valid ROI, 1 = Invalid ROI This feature will be ignored until a valid ROI is set. The ROI must be within the current image region. (See NOTE 5)
			[9..31]	Reserved
14Ch	Rotate Inquiry	Presence_Inq	[0]	Presence of this feature
		In_Desc_Inq	[1]	Can this feature have different values in different descriptors 1 = Yes, 0 = No
			[2..31]	Reserved
150h	Rotate	Offset	[0..31]	Quadlet offset of the absolute value CSR for Rotate
154h	Frame Buffer Inquiry	Presence_Inq	[0]	Presence of this feature
			[1..7]	Reserved
		Buffer_Full	[8]	0 = Buffer Empty, 1 = Buffer Full When the buffer is full the frame can be read from the camera.
			[2..31]	Reserved
158h	Buffer offset	Offset	[0..31]	Quadlet offset of the memory address for the frame data.
15Ch	Buffer Size	Value	[0..31]	Length, in bytes, of the data stored at the buffer address. This includes the size of the stored frame plus any descriptor information.

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Offset	Name	Field	Bit	Description
160h .. 1FCh	Reserved for future Feature Inquiry registers.			
ADVANCED FEATURE CONTROL REGISTERS				
200h	Descriptor Configuration	Current	[0..7]	Zero-based index of the descriptor currently in focus (Format 7 only)
		Number	[8..15]	Number of descriptors currently in use (Format 7 only) (See NOTE 6)
		Append_Desc	[16]	Append Descriptors to each frame 1 = Append, 0 = Don't Append
			[17..31]	Reserved
204h	Pixel Addressing	Value	[0..15]	Value for Pixel Addressing. Actual reduction is Base^Value except when Base = 1 then it is Value (Format 7 only)
			[16..23]	Reserved
		Mode	[24..31]	Pixel Addressing mode
208h	Flip	H_On_Off	[0]	Horizontal Flip On/Off (See NOTE 7) 1 = On, 0 = Off
			[1..15]	Reserved
		V_On_Off	[16]	Vertical Flip On/Off (See NOTE 7) 1 = On, 0 = Off
			[17..31]	Reserved
20Ch	Advanced Trigger	Source	[0]	OBSOLETE. This has been replaced with the trigger_source parameter of the trigger_mode feature in IIDC v1.31
		Type	[1]	
			[2..31]	
210h	Extended Shutter	Number	[0..7]	Number of Knee Points
			[8..31]	Reserved
214h	Look Up Table	On_Off	[0]	Lookup Table On/Off 1 = On, 0 = Off
			[1..31]	Reserved
218h	Auto ROI	On_Off	[0]	Auto ROI On/Off 1 = On, 0 = Off
			[1..31]	Reserved
21Ch	Auto ROI Position	Left	[0..15]	Left Position of the Auto ROI (Pixels)
		Top	[16..31]	Top Position of the Auto ROI (Pixels)
220h	Auto ROI Size	Width	[0..15]	Width of the Auto ROI (Pixels)
		Height	[16..31]	Height of the Auto ROI (Pixels)
224h	Rotate	On_Off	[0]	Rotate On/Off (See NOTE 7) 1 = On, 0 = Off
			[1..31]	Reserved
228h	Frame Buffer	On_Off	[0]	Frame Buffer On/Off 1 = On, 0 = Off

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Offset	Name	Field	Bit	Description
		Clear_Buffer	[1]	Clear buffer (automatically reset) 1 = Clear buffer Setting this bit will empty the buffer so that it can be filled with another frame. This bit will be cleared once the buffer is reset.
			[2..31]	Reserved mode
22Ch	Sync Cycle Time	Value	[0..31]	Value of the 1394 cycle time that when reached will cause the camera to capture a frame. This is only used in trigger mode 15. A value of 0xFFFFFFFF in this register means the camera will not begin output of a frame until a valid value is programmed.
230h .. 2FCh	Reserved for future Feature Control registers.			
GPO CONTROL REGISTERS				
300h	GPO 0 Config	On_Off	[0]	GPO 0 On/Off 1 = On, 0 = Off
		Polarity	[1]	GPO 0 Polarity 1 = Active High, 0 = Active Low
			[2..23]	Reserved
		Mode	[24..31]	GPO 0 Mode
..	..	..	..	..
300h + X*4	GPO X Config	On_Off	[0]	GPO X On/Off 1 = On, 0 = Off
		Polarity	[1]	GPO X Polarity 1 = Active High, 0 = Active Low
			[2..23]	Reserved
		Mode	[24..31]	GPO X Mode
..	..	..	..	..
338h	GPO 14 Config	On_Off	[0]	GPO 14 On/Off 1 = On, 0 = Off
		Polarity	[1]	GPO 14 Polarity 1 = Active High, 0 = Active Low
			[2..23]	Reserved
		Mode	[24..31]	GPO 14 Mode
33Ch .. 7FFh	Reserved for future Advanced Feature Control Registers			

NOTE 1:

The Feature_Id field of the Advanced Feature Access Control Register is a 48bit value with the following format:

0 – 7	8 – 15	16 – 23	24 – 31	32 – 39	40 - 47

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Company_ID (=0x000168)	Advanced_Feature_Unique_ID (=Feature offset)

For example: The Feature_Id field for the FLIP_INQ CSR would be 0x000168000114

NOTE 2:
You do not have to access the Access Control Register to Read/Write to the value at the offset pointed to by the value in this register.

NOTE 3:
These are the offsets for the absolute value CSRs for the parameters of GPO 0. The absolute value CSR offsets for GPO X can be calculated as follows : quadlet offset of Parameter **N** GPO **X** = GPO_PARM**N**_ABS + 3 * **X**.

NOTE 4:
This is the offset for the absolute value CSR for the Extended Shutter Knee Point 0. The absolute value CSR offsets for Knee Point X can be calculated as follows : quadlet offset of Knee Point **X** = XSHUT_KNEE_ABS + 3 * **X**.

NOTE 5:
In all formats the Auto ROI must be within an image region that has Top and Left coordinates of zero and Height and Width values that correspond to the current Video height and width.

NOTE 6:
Descriptors are added or removed by increasing/decreasing this value. When a descriptor is created it will have the same values as the current descriptor (Current field) or the camera settings if it is the first descriptor to be created. When the descriptor number is decreased then the descriptors with a higher index are removed first.

NOTE 7:
Changing this feature can change the orientation of the Bayer pattern. The Format 7 Color Filter ID register should be checked each time this feature is changed.

7.1 Extensions to the IIDC Version 1.31 Specification

The following sections describe PixeLINK extensions to the IIDC specification to allow for extra functionality within the IIDC address space.

7.1.1 Determining which Features can change in a Descriptor

All feature element inquiry registers (Offset 500h to 5FFh) use bit 2 to indicate if the feature can have different values in different descriptors as shown in Table 12 below.

Table 12 - Feature Element Inquiry CSRs (Section 4.5 in the IIDC 1.31 Spec.)

Offset	Name	Field	Bit	Description
5XXh	XX Inquiry Register		[0..1]	Same as IIDC Specification
		In_Desc_Inq	[2]	Can this feature have different values in different descriptors 1 = Yes, 0 = No
			[3..31]	Same as IIDC Specification

7.1.1.1 Color Coding

The Color Coding Inquiry Register uses bit 31 to indicate if the color coding can change between descriptors.

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Table 13 - Color Coding Inquiry CSR for Format_7 (Section 4.9 in the IIDC Spec.)

Offset	Name	Field	Bit	Description	
014h	Color Coding Inquiry Register	Mono8	[0]	Y only, Y=8bits, non compressed	ID=0
		4:1:1 YUV8	[1]	4:1:1, Y=U=V=8bits, non compressed	ID=1
		4:2:2 YUV8	[2]	4:2:2, Y=U=V=8bits, non compressed	ID=2
		4:4:4 YUV8	[3]	4:4:4, Y=U=V=8bits, non compressed	ID=3
		RGB8	[4]	R=G=B=8bits, non compressed	ID=4
		Mono16	[5]	Y only, Y=16bits, non compressed	ID=5
		RGB16	[6]	R=G=B=16bits, non compressed	ID=6
		Signed Mono16	[7]	Y only, Y=16bits, non compressed (signed integer)	ID=7
		Signed RGB16	[8]	R=G=B=16bits, non compressed (signed integer)	ID=8
		Raw8	[9]	Raw data output of color filter sensor, 8bits/pixel (Bayer pattern)	ID=9
		Raw16	[10]	Raw data output of color filter sensor, 16bits/pixel (Bayer pattern)	ID=10
			[9..30]		
		In_Desc_Inq	[31]	Can the Color Coding ID have different values in different descriptors 1 = Yes, 0 = No	

7.1.2 White Shading Absolute Value Registers

The IIDC 1.31 specification defines White Shading as controlling three values, the red, green and blue channel compensations, but only one absolute value register is defined for White Shading. This does not allow for control of the separate channel compensations with standard engineering units. So extra absolute value registers are defined as follows.

The offsets for the White_Shading absolute value CSRs are defined in the ABS_CSR_HI_INQ_14 register (offset 738h). This will define the offsets for the red channel compensation CSRs. The absolute value CSR offsets for the green and blue channels can be calculated as follows : quadlet offset of green or blue CSRs = ABS_CSR_HI_INQ_14 + 3 * **X** (where X = 1 for green and X = 2 for blue).

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8 Feature Modes and Values

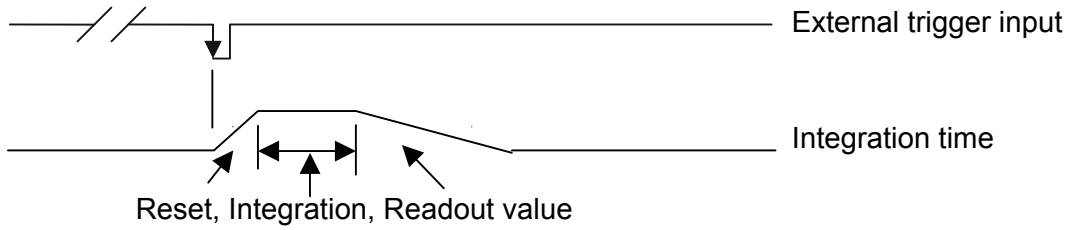
8.1 Trigger Modes

Trigger Modes 0-5 are defined by the IIDC 1.31 specification. The PL-A780 only supports Trigger Mode 0.

When the trigger is turned on, the camera is placed in fast reset shutter mode. See Section 3.2.4.2 on page 14 for more information regarding the reset and readout times.

8.1.1 Trigger Mode 0

The camera starts integration of the incoming light from external trigger input falling edge.



Integration time is described in "Shutter" register. No parameter is needed.

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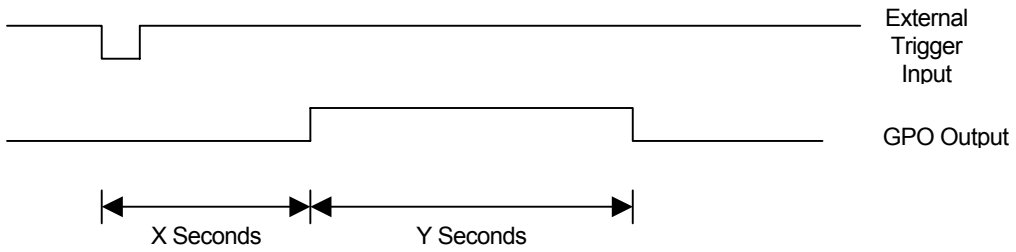
8.2 GPO Modes

The PL-A780 supported GPO modes are defined below. The PL-A780 supports modes 0 (Strobe), 1 (Normal), 3 (Busy) and 4 (Flash Window).

8.2.1 GPO MODE 0 (STROBE)

The GPO is set after a trigger occurs. The GPO pulse is delayed X (GPO Parameter 1) seconds from the trigger and is Y (GPO Parameter 2) seconds in duration.



8.2.2 GPO Mode 1 (Normal)

The GPO is set to either low or high, depending on the value of Polarity.

8.2.3 GPO Mode 3 (Busy)

The GPO is set whenever the camera is unable to respond to a trigger. This is only useful when using Trigger Type Hardware or Software, for all other modes it will always be set. The busy period is defined as the period from the time a trigger is detected until the captured frame has been read out and any internal housekeeping is completed. This mode can be used to detect missed triggers. There are no parameters.

8.2.4 GPO Mode 4 (Flash Window)

In this mode, the GPO indicates the window in which a strobe light source may be fired. The GPO signal will be set once the sensor has completed the reset and starts integrating and will be deactivated at the end of the exposure time as readout of the array commences. There are no parameters. For best results, the strobe flash duration plus any delay from the flash window pulse to the start of the strobe flash should be less than the exposure (Shutter) time.

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9 Frame Format and Descriptor Structures

9.1 Frame Format

A frame coming from the camera will have the following format:

Byte 0	Byte 1	Byte 2	…	Byte N-2	Byte N-1
Frame Descriptor (See Descriptor Structure Format)					

= IIDC 1.31 Frame padding region

N = Number of bytes per frame (width * height * bytes per pixel)

If multiple descriptors are being used then a synchronization code will be encoded in the first four pixels. This code is to ensure that the driver knows which frame it is receiving from the camera (in case the frame size changes between descriptors). The code is encoded as:

Byte 0	Bits 7 … 0	
Byte 1	Bits 7 … 1	Code Bit 7
Byte 2	Bits 7 … 0	
Byte 3	Bits 7 … 1	Code Bit 6
Byte 4	Bits 7 … 0	
Byte 5	Bits 7 … 1	Code Bit 5
Byte 6	Bits 7 … 0	
Byte 7	Bits 7 … 1	Code Bit 4
Byte 8	Bits 7 … 0	
Byte 9	Bits 7 … 1	Code Bit 3
Byte 10	Bits 7 … 0	
Byte 11	Bits 7 … 1	Code Bit 2
Byte 12	Bits 7 … 0	
Byte 13	Bits 7 … 1	Code Bit 1
Byte 14	Bits 7 … 1	
Byte 15	Bits 7 … 1	Code Bit 0

where Code is a 8 bit number (Bit 7 = MSB). The Code is zero for the first frame of a video stream, and will increment by one each frame after that, rolling over once it reaches the number of descriptors currently in use (i.e. if three descriptors are in use then the Code will roll over once it reaches 2).

9.1.1 Byte Order

For 8-bit data, the byte order is straight forward with byte 0 being the top left pixel in the image, byte 1 being the second pixel in the top row and so on.

The FireWire bus uses big-endian notation, that means that the most significant byte comes first and the most significant bit is bit 0. The PC uses little endian notation, where the least significant byte comes first. Hence, on a PC system, when receiving 16-bit data from the camera, the bytes will be swapped.

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The following C code example swaps the bytes and strips the trailing zeros to leave a 10-bit pixel value in the range of 0 to 1023.

```
// Swap bytes and shift right to get a value in the range [0,1023]
inline U16 SwapAndShiftU16(U16 val)
{
      return ((val & 0xFF) << 2) | ((val & 0xFF00) >> 14);
}
```

When interpreting image data from the camera, the Video Format (Section 5.1.2) or Color Coding (Section 5.1.3.2) is used to determine the meaning and order of the data. In addition, for Raw data formats, the Color Filter ID can be used to determine the order of the color channels in the image. This is relevant for cameras that can flip or rotate the image data. See the IIDC Specification - offset 058h from the Video Mode CSR for Format 7.

For the PL-A780 series cameras which do not support flip or rotate, the color data will always be output with Filter ID = 2 (GR/BG) format.

9.2 Descriptor Structure Format

The Descriptor structure has two parts. The first part contains a list of all the features that can change between descriptors and all other features in the second. The first section of the structure is attached to the end of each frame sent to the driver. This part of the structure is required to be as small as possible so only features that could change from frame to frame and be unknown by the Host are included (i.e. features that could be in Auto mode).

The whole structure (first and second section) is used when accessing the Descriptor structure located at the Descriptor Offset (See Table 11 on page 46).

The PL_A780 uses Descriptor Version 3. Versions 0 through 2 are subsets of this structure and are used by other PixeLINK cameras. Refer to the PixeLINK API Reference Manual for more information.

9.2.1 Descriptor Version 0x0003

```
typedef struct _DESCRIPTOR
{
      const U16 wSize;              // Size of this structure (in
      bytes)
      const U16 wVersion = 0x0003;  // Version of this structure

      float fWhiteBalance;          // White Balance
      float fSaturation;            // Saturation
      float fBrightness;            // Brightness
      float fShutter;               // Shutter
      float fGain;                  // Gain
      float fRedGain;               // Red Gain
      float fGreenGain;             // Green Gain
      float fBlueGain;              // Blue Gain

#if FRAME_STRUCTURE
} DESCRIPTOR, *PDESCRIPTOR;
#else // !FRAME_STRUCTURE
      // This section contains all settings that don't change without
```


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```
        // the host's knowledge
        float fAutoExposure;          // Auto Exposure
        float fSharpness;             // Sharpness
        float fHue;                   // Hue
        float fGamma;                 // Gamma
        float fIris;                  // Iris
        float fFocus;                 // Focus
        float fTemperature;           // Temperature
        float fTriggerParamter;       // Parameter for Trigger
        float fTriggerDelay;          // Trigger Delay
        float fZoom;                  // Zoom
        float fPan;                   // Pan
        float fTilt;                  // Tilt
        float fOpticalFilter;         // Optical Filter
        float fAutoROILeft;           // Auto ROI Left
        float fAutoROITop;            // Auto ROI Top
        float fAutoROIWidth;          // Auto ROI Width
        float fAutoROIHeight;         // Auto ROI Height
        float fRotate;                // Angle of Rotation

        float fFrameRate;             // Frame Rate
        float fLeft;                  // ROI Left
        float fTop;                   // ROI Top
        float fWidth;                 // ROI Width
        float fHeight;                // ROI Height
        float fPixelAddressingValue;  // Pixel Addressing Value
        float fPixelAddressinMode;    // Pixel Addressing Mode
        float fPixelFormat;           // Pixel Format
        float fKneePoint[4];          // Extended Shutter Knee Point
        float fGPOParameter1[16];     // GPO Parameter 1
        float fGPOParameter2[16];     // GPO Parameter 2
        float fGPOParameter3[16];     // GPO Parameter 3
        U8 byGPOMode[16];       // GPO Mode
        U8 byGPOPolarity[16];         // GPO Polarity
        U8 byTriggerMode;             // Trigger Mode
        U8 byTriggerPolarity;         // Trigger Polarity
        U8 byTriggerType;             // Trigger Type
        U8 byReserved;                // Padding to quadlet align

} DESCRIPTOR, *PDESCRIPTOR;
#endif // FRAME_STRUCTURE
```


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10 Technical Notes & Support

Tech Notes

Tech Notes on a variety of topics are available on our Web site, at http://www.pixelink.com/.

Download the Latest Software and Firmware

The PL-A780's onboard programming (firmware) can be upgraded at your computer. Whether you have a tech support issue or not, we recommend that you check our Web site (http://www.pixelink.com/) regularly for the latest versions of your PixeLINK software and firmware.

Technical Questions

Please follow these steps before contacting our technical support team:

1. Review the relevant sections of the documentation.
2. Check the PixeLINK Web site for:
    a. new software and firmware;
    b. applicable Tech Notes.
3. Carefully document the problem you are experiencing, noting any warning or error messages that may appear during operation.
4. Have your Camera's serial number, where the camera was purchased and other identifying information at hand. The serial number can be found on bottom of the Camera.

PixeLINK Customer Support

Email: support@pixelink.com
Web: http://www.pixelink.com/

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Appendix A. Glossary

1394	A short form description for the IEEE 1394 FireWire bus.
Bayer pattern or filter	Color filters arranged in a mosaic pattern that allows three color channels to be detected in an array of pixels.
API	Application Programming Interface
Decimation	The process of skipping pixel data in the image to reduce the image size.
DLL	Dynamic Link Library
Field of View	A term that refers to the relative angular size of an image.
FireWire	Apple Computer's trademark for the IEEE 1394 digital bus protocol
GPO	General Purpose Output
IEEE	Institute of Electrical and Electronics Engineers
Integration	The process of building up, or integrating, an electrical charge in response to the photons incident to a pixel.
FPN	Fixed pattern noise
fps	The frame rate in frames per second.
MB	Megabyte
MHz	Megahertz
PRNU	Photo response non-uniformity
RAM	Random Access Memory
Resolution	The number of pixels in an image.
RGB	Standard for encoding color images (Red, Green, Blue)
Sensor	The Camera's image sensing chip
ROI	Region of Interest—The portion of the imager area that is active.
Video stream	The video image data sent over the FireWire bus (cable) from the camera to the host computer. This is the source of data for the preview window and any captured images or video clips.

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